APPENDIX B4

Construction Soil and Water Quality Management Plan

Early Works – Wave 1 & 3 (part) Woolgoolga to Ballina

Pacific Highway Upgrade

DECEMBER 2015

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Glossary/Abbreviations

CEMP	Construction Environmental Management Plan
CoA	Condition of Approval
CSWQMP	Construction Soil and Water Quality Management Plan
DPI	Department of Primary Industries (Fishing and Aquaculture)
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPL	Environment Protection Licence
ERSED	Erosion and sedimentation
ESCP	Erosion and Sediment Control Plan
EWMS	Environmental Work Method Statements
FM Act	*Fisheries Management Act 1994*
Golding	Golding Contractors Pty Ltd
Minister, the	Minister for Planning
NOW	NSW Office of Water
OEH	Office of Environment and Heritage
Project, the	Early Works – Wave 1 & 3 (part), Woolgoolga to Ballina, Pacific Highway Upgrade
RMS	NSW Roads and Maritime Services
Secretary	Secretary of the Department of Planning and Environment (formerly known as the Director General)
SPIR	Submissions / Preferred Infrastructure Report

1 Introduction

1.1 Context

This Construction Soil and Water Quality Management Plan (CSWQMP or Plan) forms part of the Construction Environmental Management Plan (CEMP) for the Early Works - Wave 1 and part of Wave 3 Project, which is part of the upgrade of the Pacific Highway between Woolgoolga and Ballina.

This CSWQMP has been prepared to address the requirements of the Minister's Conditions of Approval (CoA) and the mitigation measures listed in the Pacific Highway Upgrade Woolgoolga to Ballina Environmental Impact Statement (EIS), Submissions/Preferred Infrastructure Report (SPIR) and all applicable legislation.

This Plan has been prepared for Wave 1 and 3 (part) of the Project which broadly includes:

- Ground treatment and preparatory earthworks (soft soils treatments) between STN 83400 and 91200.
- Excavation of material taken from a highway cutting at Tyndale (at approximate STN 69000 to 69500) for the soft soil treatments.
- Excavation of material taken from highway cuttings north of McIntyres Lane, Gulmarrad (at approximate STN 77500 to 78400) for the soft soil treatments.
- Excavation of material south of McIntyres Lane, Gulmarrad - Greenhills cutting (at approximate STN 76000 to 77075) for the soft soil treatments. McIntyres Lane would be widened to support truck movements from this cutting.
- Relocation of utility services at various locations throughout STN 67200 to 95100.

These works are located within Sections 4 and 5 of the Approved Project.

1.2 Background

The EIS assessed the impacts of construction and operation of the Project on soils and water within Chapters 8 and 9.

As part of EIS development, detailed groundwater and water quality assessments were prepared to address the Environmental Assessment Requirements issued by the Department of Planning and Infrastructure. These assessments were included in the EIS as Working Paper: Water Quality, Working Paper: Hydrology and Flooding and Working Paper: Groundwater.

The EIS identified the potential for direct and indirect impacts on water quality but concluded that, with implementation of appropriate impact mitigation measures; there would be no significant impacts to waterways crossed by the project, or to high risk areas or sensitive receiving environments downstream of the project.

Additional management measures were provided within the *Woolgoolga to Ballina Submissions / Preferred Infrastructure Report Nov 2013*, with applicable management measures from that report included as part of this CSWQMP.

1.3 Environmental management systems overview

The overall Environmental Management System for the Project is described in the Construction Environmental Management Plan (CEMP).

The CSWQMP is part of the Golding environmental management framework for the Project, as described in *Section 4.1 of the CEMP*. In accordance with CoA D25, this Plan has been developed in consultation with EPA, DPI (Fisheries NSW), NOW, and the relevant councils.

Management measures identified in this Plan will be incorporated into site or activity specific Environmental Work Method Statements (EWMS) and Erosion and Sediment Control Plans (ESCP).

EWMS will be developed and signed off by environment and management representatives prior to associated works and construction personnel will be required to undertake works in accordance with the identified safeguards. For high risk activities, such as construction of working platforms in waterways, EWMS will be provided to EPA and DPI Fisheries Conservation and Aquaculture for input prior to sign off (refer to *Section 4.1.3 of the CEMP*).

ESCP are designed for use as a practical guide and may be produced in conjunction with Environmental Work Method Statement (EWMS) to provide more detailed site-specific environmental mitigation measures. ESCP will be developed by the environment team in consultation with construction personnel and the Project Soil Conservationist, and modified as required when:

- Site conditions evolve.
- Flow paths change.
- Construction activities that affected the characteristics of ground conditions change.

Used together, the CEMP, strategies, procedures, EWMS and ESCP form management guides that clearly identify required environmental management actions for reference by Golding personnel and sub-contractors.

This CSWQMP has been developed by personnel with skills and experience in preparing CSWQMPs in accordance with the Blue Book.

The review and document control processes for this Plan are described in *Sections 1.6, 9 and 10 of the CEMP*.

2 Purpose and objectives

2.1 Purpose

The purpose of this Plan is to describe how construction impacts on soil and water will be minimised and managed.

2.2 Objectives

The key objective of the CSWQMP is to ensure that impacts on water quality are minimised and within the scope permitted by the planning approval. To achieve this objective, Golding will undertake the following:

- Ensure best management practice controls and procedures are implemented during construction activities to avoid or minimise erosion/sedimentation impacts and potential impacts to water quality in rivers, creeks and groundwater along the Project corridor.
- Ensure appropriate measures are implemented to address the relevant CoA outlined in Table 3.1 and the safeguards detailed in the EIS and Submission/Preferred Infrastructure Report (SPIR).
- Ensure appropriate measures are implemented to comply with all relevant legislation and other requirements as described in Section 3.1 of this Plan.

2.3 Targets

The following targets have been established for the management of soil and water impacts during the project:

- Ensure full compliance with the relevant legislative requirements and CoA.
- Meet environment protection licence water quality discharge parameters for all planned basin discharges (ie those within design capacity).
- Manage downstream water quality impacts attributable to the project (ie maintain waterway health by avoiding the introduction of nutrients, sediment and chemicals outside of that permitted by the environment protection licence and/or ANZECC guidelines).
- Ensure training on best practice soil and water management is provided to all construction personnel through site inductions.

3 Environmental requirements

3.1 Relevant legislation and guidelines

3.1.1 Legislation

Legislation relevant to soil and water management includes:

- *Environmental Planning and Assessment Act 1979* (EP&A Act).
- Environmental Planning and Assessment Regulation 2000.
- *Protection of the Environment Operations Act 1997*.
- *Water Management Act 2000.*
- *Fisheries Management Act 1994.*
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*
- *Water Act 1912*.

Relevant provisions of the above legislation are explained in the register of legal and other requirements included in Appendix A1 of the CEMP.

3.1.2 Guidelines and standards

The main guidelines, specifications and policy documents relevant to this Plan include:

- Acid Sulfate Soil Manual (ASSMAC 1998).
- Acid Sulfate Soil and Rock – Victorian EPA Publication 655.1 – July 2009.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000).
- Department of Environment and Conservation (DEC): Bunding & Spill Management. Insert to the Environment Protection Manual for Authorised Officers - Technical section "Bu" November 1997.
- Managing Urban Stormwater: Soils and Construction. Landcom, (4th Edition) March 2004 (reprinted 2006) (the "Blue Book"). Volume 1 and Volume 2.
- Volume 2A Installation of Services (DECCW 2008).
- Volume 2C Unsealed Roads (DECCW 2008).
- Volume 2D Main Roads Construction (DECCW 2008).
- DIPNR Roads and Salinity Guideline, 2003.
- DLWC, 1998. Constructed Wetlands Manual.
- Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings. NSW Fisheries, Cronulla, 16 pp.
- *NSW Fisheries, November 2003. Fishnote – Policy and Guidelines for Fish Friendly* Waterway Crossings (Ref: NSWF – 1181).
- RMS Dewatering Guideline.
- RMS Pacific Highway Practice Note for Dewatering.

- RTA's Code of Practice for Water Management – Road Development and Management (1999).
- Approved Methods for the Sampling and Analysis of Water Pollutants in NSW – March 2004.
- Guidelines for the Management of Acid Sulphate materials: Acid Sulphate Soils, Acid Sulphate Rock and Monosulphidic Black Ooze (RTA 2005).
- RMS Environment Direction Management of Tannins from Vegetation Mulch.
- Stockpile Site Management Guideline, RMS 2011.
- Environmental Best Management Practice Guideline for Concreting Contractors, DEC, 2004.

3.2 Minister's Conditions of Approval

The CoA relevant to this Plan are listed Table 3-1. A cross reference is also included to indicate where the condition is addressed in this Plan or other Project management documents.

Table 3-1 Conditions of Approval relevant to the CSWQMP

CoA No.	Condition requirements	Document reference
B34	**Construction Soil and Water Management** Soil and water management measures consistent with *Managing Urban Stormwater - Soils and Construction Vols. 1 and 2, 4th Edition* (Landcom, 2004) and *Managing Urban Stormwater Soil and Construction Vols. 2A and 2D Main Road Construction* (Department of Environment and Climate Change, 2008) shall be employed during the construction of the SSI to minimise soil erosion and the discharge of sediment and other pollutants to land and/or waters.	This plan
B35	Where available, and of appropriate chemical and biological quality, stormwater, recycled water or other water sources shall be used in preference to potable water for construction activities, including concrete mixing and dust control.	This plan
B36	All surface water and groundwater shall be adequately treated as far as is practicable, prior to entering the stormwater system to protect the receiving water source quality.	This plan
B37	Prior to the commencement of site preparation and excavation activities, or as otherwise agreed by the Secretary, in areas identified as having a moderate to high risk of contamination, a site audit shall be carried out by a suitably accredited contaminated site auditor. A **Site Audit Report** is to be prepared by the site auditor detailing the outcomes of Phase 2 contamination investigations within these areas. The Site Audit Report shall detail, where relevant, whether the land is suitable (for the intended land use) or can be made suitable through remediation. Where the investigations identify that the site is suitable for the intended operations and that there is no need for a specific remediation strategy, measures to identify, handle and manage potential contaminated soils, materials and groundwater shall be identified in the Site Audit Report and incorporated into the Construction Environmental Management Plan. Where the investigations identify that the site is suitable for the intended operations and that a remediation strategy is required, the Site Audit Report shall include a remediation strategy for addressing the site	Appendix B10

CoA No.	Condition requirements	Document reference
	contamination, and how the environmental and human health risks will be managed during the disturbance, remediation and/or removal of contaminated soil or groundwater, and be incorporated into the Construction Environmental Management Plan. Where remediation is required, a **Site Audit Statement(s)** shall be prepared verifying that the site has been remediated to a standard consistent with the intended land use. *Note* *Terms used in this condition have the same meaning as in the Contaminated Land Management Act 1997.*	
B38	**Watercourse crossings** Watercourse crossings shall be designed in consultation with the DPI (Fisheries NSW), EPA, NOW and DoE, and where feasible and reasonable, be consistent with the *Guidelines for Controlled Activities Watercourse Crossings* (Department of Water and Energy, February 2008*)*, *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge, 2003), *Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries, February 2004*),* and *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries, 2013). Where multiple cell culverts are proposed for crossings of fish habitat streams, at least one cell shall be provided for fish passage, with an invert or bed level that mimics watercourse flows.	This plan
D12	The Applicant shall prepare and implement a **Water Quality Monitoring Program**, to monitor the construction and operation impacts of the SSI on surface and groundwater quality and resources and wetlands, prior to construction. The Program shall be prepared in consultation with the OEH, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields), to the satisfaction of the Secretary, and shall include but not necessarily be limited to: a) Identification of surface and groundwater quality monitoring locations (including watercourses, waterbodies and SEPP14 wetlands) which are representative of the potential extent of impacts from the SSI. b) The results of any groundwater modelling undertaken. c) Identification of works and activities during construction and operation of the SSI, including emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and known Oxleyan Pygmy Perch habitat. d) Development and presentation of parameters and standards against which any changes to water quality will be assessed, having regard to the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (Australian and New Zealand Environment Conservation Council, 2000) or relevant baseline data. e) Representative background monitoring of surface and groundwater quality parameters for a minimum of 12 months (considering seasonality) prior to the commencement of construction, to establish baseline water conditions, unless otherwise agreed by the Secretary. f) A minimum monitoring period of three years following the completion of construction or until the affected waterways and/or	Appendix A Appendix L

CoA No.	Condition requirements	Document reference
	groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition. The monitoring shall also confirm the establishment of operational water control measures (such as sedimentation basins and vegetation swales). g) Contingency and ameliorative measures in the event that adverse impacts to water quality are identified. h) Reporting of the monitoring results to Department of Planning and Environment, OEH, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields).	
D13	The Applicant shall prepare and implement a **Hydrological Mitigation Report** for properties where flooding and/or hydrological impacts are predicted to exceed the relevant flood management objective in the documents listed in condition A2 as a result of the SSI. The Report shall be prepared by a suitably qualified expert and be based on detailed surveys (eg floor levels) and associated assessment of potentially flood affected properties in the Corindi, Clarence and Richmond river floodplains. The Report shall: a) Identify properties in those areas likely to have an increased/exacerbated impact and detail the predicted impact; The types of impacts to be considered include all those examined in the EIS including but not limited to changes in flood levels and velocities, alteration to drainage, reduction in flood evacuation access or capability, impacts on infrastructure, impacts on stock and agriculture, and impacts to the environment. b) Identify mitigation measures to be implemented to address these impacts. c) Identify measures to be implemented to minimise scour and dissipate energy at locations where flood velocities are predicted to increase as a result of the SSI and cause localised soil erosion and/or pasture damage. d) Be developed in consultation with the relevant council, NSW State Emergency Service and directly-affected landowners. e) Identify operational and maintenance responsibilities for items a) to c) inclusive. f) Refer to the assessments described in conditions B31 andB32. The report may be submitted in stages to suit the staged construction of the SSI. Construction shall not commence within those areas likely to have altered flood conditions until such time as works identified in the hydrological mitigation report have been completed, unless otherwise agreed by the Secretary.	Appendix M
D14	Based on the mitigation measures identified in condition D13, the Applicant shall prepare and implement a final schedule of feasible and reasonable flood mitigation measures proposed at each directly-affected property in consultation with the landowner. The schedule shall be provided to the relevant landowner(s) prior to the implementation/construction of the mitigation works, unless otherwise agreed by the Secretary. A copy of each schedule of flood mitigation measures shall be provided to the Department of Planning and Environment and the relevant council prior to the implementation/construction of the mitigation measures on the property.	Appendix N
D15	The Applicant shall employ a suitably qualified and experienced independent hydrological expert, whose appointment has been endorsed	This plan

CoA No.	Condition requirements	Document reference
	by the Secretary, to deal with all hydrological matters and assist landowners in negotiating feasible and reasonable mitigation measures.	
D16	The Applicant shall provide feasible and reasonable assistance to the relevant council and/or NSW State Emergency Service, to prepare any new or necessary update(s) to the relevant plans and documents in relation to flooding, to reflect changes in flooding levels, flows and characteristics as a result of the SSI.	This plan
D26 (c)	A **Construction Soil and Water Quality Management Plan** to manage surface and groundwater impacts during construction of the SSI. The Plan shall be developed in consultation with the EPA, DPI (Fisheries), NOW, Rous Water (in relation to the Woodburn borefield), DoE and the relevant council and include, but not necessarily be limited to: a) Details of construction activities and their locations, which have the potential to impact on water courses, storage facilities, stormwater flows, and groundwater. b) Surface water and ground water impact assessment criteria consistent with Australian and New Zealand Environment Conservation Council (ANZECC) guidelines or relevant site specific baseline data collected for known Oxleyan Pygmy Perch waterways. c) Management measures to be used to minimise surface and groundwater impacts, including details of how spoil and fill material required by the SSI will be sourced, handled, stockpiled, reused and managed; erosion and sediment control measures; salinity control measures and the consideration of flood events. d) A **Groundwater and Soil Salinity report** should geotechnical investigations determine the presence, extent and severity of soil salinity within the SSI boundary, The report shall detail the outcomes of geotechnical investigations and identify and mitigate impacts to groundwater resources. e) An **Acid Sulfate Soils contingency plan**, consistent with the *Acid Sulfate Soils Manual*, to deal with the unexpected discovery of actual or potential acid sulfate soils, including procedures for the investigation, handling, treatment and management of such soils and water seepage. f) A **tannin leachate management protocol** to manage the stockpiling of mulch and use of cleared vegetation and mulch filters for erosion and sediment control. g) An **Oxleyan Pygmy Perch habitat waterway management framework** to detail the measures and construction methods that will be employed to avoid direct discharge of construction water to known Oxleyan Pygmy Perch habitat waterways and downstream impacts to suitable habitat. h) Management measures for contaminated material and a contingency plan to be implemented in the case of unanticipated discovery of contaminated material during construction. i) A description of how the effectiveness of these actions and measures would be monitored during the proposed works, clearly indicating how often this monitoring would be undertaken, the locations where monitoring would take place, how the results of the monitoring would be recorded and reported, and, if any exceedance of the criteria is detected how any non-compliance can be rectified j) Mechanisms for the monitoring, review and amendment of this plan.	This plan and Appendices B10 and B11

4 Existing environment

The following sections summarise what is known about factors influencing soils and water within and adjacent to the Project corridor.

The key reference documents are Chapters 8 and 9 of the EIS, Working Paper: Water Quality, Working Paper: Hydrology and Flooding and Working Paper: Groundwater.

4.1 Topography and soil characteristics

The topography throughout the project can be broadly categorised as 'lowland' associated with the Clarence River floodplain, with elevations less than 15 metres AHD. The exception is the cutting at Tyndale, which is located on elevated ground.

The project generally traverses the geological sequence of the Clarence-Moreton Basin, an extensive Mesozoic age sedimentary basin extending from southern Queensland to the NSW North Coast and comprising sedimentary rocks about 2.5 to 4.0 kilometres thick.

The Jurassic age Walloon Coal Measures outcrop generally parallel to the coastline in elevated and steeper terrain areas of north-eastern NSW and are known to result in slope instability in some areas. Section 4 of the project traverses Walloon Coal Measures and may therefore have elevated levels of slope instability. Section 5 of the project however traverses relatively flat, low-lying areas and rolling hills. Slope stability issues are not considered likely in these areas.

The most common soil landscapes within the project boundary are the erosional, transferral and alluvial types. Soils within these landscapes are generally highly erodible and have low bearing strength. Soft soils occur in low-lying areas, including the Clarence River floodplain.

Topography and soils for each project section are also outlined in Table 4-1.

Table 4-1 Topography and soils

Section	Topography	Soil type	Soil characteristics
4	Lowland	No published soil landscape map is available for the southern portion of this section. The northern portion is underlain by swamp and alluvial landscapes at lower elevations (ie <5m) and erosional landscapes at higher elevations near Maclean.	Highly erodible Presence of soft soils throughout the Clarence River floodplain.
5	Lowland	Mainly underlain by estuarine landscapes of the Clarence River delta and associated floodplains. An area of disturbed landscape located on the southern bank of the Clarence River at the south of the section.	Prone to water erosion.

4.2 Surface water

The project is located on the Clarence River floodplain and is in close proximity to numerous open channels, creeks and wetlands, as well as the river itself. Some of the receiving waters drain to or support sensitive aquatic and riparian environments including key fish habitats and wetlands listed under SEPP 14.

Major waterways are outlined in Table 4-2 and are shown on the sensitive area maps attached at Appendix A5 of the CEMP.

Existing water quality monitoring data for waterways within each section was reviewed as part of the EIS. The existing water quality data indicate that the majority of the waterways potentially impacted by the project have a history of water quality problems, with conditions commonly found to be below the standard required for protection of aquatic ecosystems. The occurrence of poor water quality can be attributed to a number of factors, including modification of channel structure, macrophyte and weed growth, soil erosion, acid sulphate soils and nutrient enrichment as a result of runoff from agricultural land.

A pre-construction water quality monitoring program has been undertaken. This data will be used to evaluate broader water quality trends throughout and following construction of the project. The water quality monitoring program to be implemented during and following construction is provided as Appendix A. The water quality monitoring program includes a summary of the pre-construction water quality monitoring results.

A broad qualitative evaluation of water quality from the EIS is provided in Table 4-2. The pre-construction water quality monitoring results are generally consistent with the summaries provided below.

Table 4-2 Watercourses, wetlands and water quality

Section	Waterways	Summary of water quality
4	• South Arm (Clarence River) • Edwards Creek • Shark Creek	Wet and dry weather samples were taken from South Arm, Edwards Creek and Shark Creek during 2007. Water quality was found to be generally poor and failed to meet the ANZECC/ARMCANZ guidelines. Possible reasons for poor water quality included low flow, channel modification, bank erosion, weed growth, and drainage from acid sulfate soils.
5	• James Creek • Nyrang Creek • Clarence River • Serpentine Channel • North Arm (Clarence River) • Mororo Creek	Samples taken from waterways in this section between 2005 and 2007 indicated that water quality was generally good. The main exception was the water quality in Serpentine Channel, which failed to meet ANZECC/ARMCANZ guidelines for turbidity, pH and Dissolved Oxygen (DO). North Arm was generally good, although turbidity was high during wet weather. Agricultural use of floodgates and cane drains could also contribute to poor water quality.

4.3 Groundwater

Alluvial deposits occur throughout the area within the project boundary, laid down by the Clarence River, which emanates from the Great Dividing Range. The floodplain is commonly capped with clay-rich deposits of variable thickness, which form an impermeable seal to the underlying sands, gravels and other sediments.

Recharge to the coastal sediments is generally considered to be via direct infiltration of rainfall and floodwaters, though the impermeable nature of the surface clays in many areas means that localised recharge is probably the dominant recharge mechanism.

Groundwater levels within the lowland areas of the project boundary are typically within three metres of the surface. On the floodplain of the Clarence River, groundwater levels can be two metres from the surface. Following periods of heavy rainfall, the groundwater levels in lowland and floodplain areas are often at the existing ground surface. The water-bearing units in these areas are generally associated with alluvial aquifers on low-lying, alluvial deposits.

In elevated areas underlain by bedrock, groundwater levels are typically more than eight metres below the surface. The water-bearing units in these areas are generally deep within the rock formations (that is, greater than 10 to 15 metres below the surface).

Of nearly 10,000 bores investigated as part of the EIS:

- Less than three per cent of bores have an allocation for irrigation and an additional one per cent is licensed to extract groundwater for commercial ventures. Combined, this accounts for an entitlement of 30 gigalitres per year, though only an estimated 8.5 gigalitres was used in 2010–11.
- Eighty-five percent of registered bores are licensed for stock and domestic use, with an annual entitlement of generally one to three megalitres per year each (but up to 14 megalitres per year in one case).
- Ten per cent of bores are rated as ‘lapsed’ or ‘cancelled’ and the remainder are monitoring or test bores with no water use requirements.

Under normal climatic conditions, groundwater is a minor water source, with surface water supplies sufficient for most operations. However, during periods of drought, as occurred between 2000 and 2007, groundwater becomes an increasingly important water source.

4.4 Rainfall

The rainfall records from the Harwood Island Station (BoM Station No. 058027) have been selected to reflect the potential rainfall conditions across the Project site due to its location within the overall site and extent of available data (from 1915 to present). A summary of the rainfall records from this site is provided in Table 4-3.

Table 4-3 Summary of rainfall records

	Summer/autumn						Winter/spring						
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean rainfall (mm)	142	166	171	137	130	109	72	56	49	72	98	111	**1314**
Mean rain days	9.9	10.5	12.1	9.8	8.7	7.4	5.9	5.2	5.4	6.6	7.9	9.0	**98.4**

Rainfall is typically higher during summer and autumn. Winter and spring are typically drier periods during the year.

Where practicable actual R(Y%,5-day) values will be determined for each area based on an analysis of local rainfall records. The Blue Books (Landcom, 2004) values for Grafton are:

- Five-day 80th %ile rainfall depth: 29.0 mm.
- Five-day 85th %ile rainfall depth: 37.2 mm.

4.5 Rainfall erosivity factor

The rainfall erosivity factor is a measure of the ability of rainfall to cause erosion (referred to as “R” in the Revised Universal Soil Loss Equitation RUSLE). The rainfall erosivity factor is used to determine the soil loss in tonnes per hectare over one year, and is used in calculations when sizing construction sediment basins. The Project has a rainfall erosivity factor of 3,600 which about the median value encountered in Australia.

4.6 Flooding

The project is located in the Clarence River catchment area, which is subject to frequent and extensive flooding caused by one or a combination of:

- Rainfall in the upper catchment.
- Rainfall in the local catchment.
- Large ocean tides.

Flooding is generally concentrated on and around the coastal floodplains and inundation in these areas can extend over a number of weeks. This can result in damage to buildings and roads, loss or stranding of livestock, loss of crops and blocked access. Flooding also occurs in some upper catchment waterways where fast flows and rapid changes to creek levels can eventuate.

In some areas, local authorities have constructed levees, flood gates and other features to manage the effects of flooding. Levees provide some protection from Clarence River flooding for Grafton, South Grafton, Ulmarra and Maclean, but other towns such as Cowper, Brushgrove, Tucabia and Harwood are not protected.

Hydrological and hydraulic models were used to simulate flows and flood behaviour for all mapped watercourses and associated floodplains crossed by the project (refer to Section 8.2 of the EIS). Over 15 different models were used, with the model type depending upon the size and characteristics of the waterway being examined.

The level of the existing highway is below the 20 year ARI flood event level in many locations. This means that the highway can be inundated by floodwaters during a 20 year ARI flood event.

Details of flood investigation areas and flood events assessed (two year, five year, 20 year, 50 year 100 year and 200 year ARI events) are included in Table 8-2 of the EIS, and more broadly in Chapter 8 of the EIS. The impacts associated with flood events in between these events or smaller than the two or five year ARI flood events can be generally estimated by interpolation or extrapolation of these results. The exceptions to the relationship described above are on the Clarence and Richmond river floodplains. Here, the floodplain flows are quite complex with considerable interaction between floodplain flow paths over a range of flood events.

Chapter 8.3 of the EIS includes an assessment of construction impacts in relation to hydrology and flooding. This includes the following:

- Ancillary sites (Chapter 8.3.1): the proposed compound site for the Wave 1 & 3 (part) Project is located at Chatsworth Road. This site is on the floodplain below the level of the 20 year ARI flood and could therefore be affected by flooding and have hydrology and flooding impacts on upstream areas. This site needs to be built up on an embankment to provide sufficient flood immunity.
- Clarence River soft soil sites (Chapter 8.3.2): the primary scope of the Wave 1 & 3 (part) Project is to undertake early construction of road embankments at soft soil treatment sites to accelerate the settlement of soft soils.
- Construction of temporary connections to existing highway (Chapter 8.3.3).
- Construction of sites and haul roads - impacts on cane drains (Chapter 8.3.4).

Conditions of approval specifically relating to flooding have been received for the project. These CoA are to be addressed outside of the scope of this CSWMP. They consist of the following:

- **B31**: the hydrological and flooding impacts resulting from the SSI are to be assessed during detailed design against the 'Design Objectives for Flood Management' described in Section 2.1 of the EIS's ' Working Paper - Hydrology and Flooding'. This shall include assessment against the 'Flood Management Objectives' and the 'Other Flood Impact Considerations' as well as the other requirements of this section of the EIS. This hydrology assessment shall include the refinement of or development of new flood models (where required) for the 14 catchments investigated during the EIS. These models shall be operated for the same design floods considered in the EIS, as well as the 2000 year ARI and the probable maximum flood (PMF) design events.
- **B32**: for the Corindi, Shark Creek and Farlows Flat areas, flooding and hydrological impacts resulting from existing highway infrastructure shall be assessed. As part of this assessment, flood models shall assess the impacts of recent highway upgrades in this area. Where the existing highway in these areas has resulted in adverse flooding and/or hydrological impacts, opportunities to reduce the quantum of these impacts shall be considered during the detailed design of the SSI, where it is feasible and reasonable to do so.
- **B33**: where the objectives and considerations referred to in condition B31 cannot be complied with, the Applicant shall:
    a) Achieve compliance through modified embankment or drainage design. This might include new or duplicated drainage structures designed to minimise afflux and other impacts to waterways that traverse the road alignment, to the greatest extent practicable, or
    b) Achieve an acceptable level of mitigation of impacts through alternative design measures (eg raised access tracks) in consultation with the affected land-owner, or
    c) Reach agreement with affected landowners on impacts to property.

Conditions of approval relating to the Hydrological Mitigation Report (CoA D13, CoA D14, CoA D15, and CoA D16), hydrological expert and changes to flood modelling are included in Table 3-1.

5 Environmental aspects and impacts

5.1 Construction activities

Key aspects of the Project that could result in adverse impacts to soils and water include:

- Vegetation clearing and topsoil stripping.
- Mulching of vegetation.
- Bulk earthworks.
- Blasting.
- Site access including temporary waterway crossings.
- Culvert and drainage works.
- Underboring of waterways
- Material stockpiles including the treatment of acid sulphate soil and rock.
- Water use/extraction.
- Compounds operation including fuel and chemical storage, refuelling and chemical handling.
- Noxious weed treatment including herbicide spraying.

Refer also to the Aspects and Impacts Register included in Appendix A2 of the CEMP.

5.2 Potential Impacts

The potential for impacts on soil and water will depend on a number of factors. Primarily impacts will be dependent on the nature, extent and magnitude of construction activities and their interaction with the natural environment. Potential impacts attributable to construction might include:

- Exposure of soils during vegetation clearing and earthworks, creating the potential for off-site transport of eroded sediments and pollutants.
- Sensitive area damage from inappropriate stockpiling activities.
- Production of tannins from mulch during clearing.
- Disturbance of acid sulphate soils, creating the potential for oxidation of these soils and subsequent generation of acidic run-off.
- Alteration of surface and subsurface flows that could cause disturbances to hydrology and hydraulics.
- Intercepting with cuts perched water tables or layers of relatively low permeability soil/rock that support surrounding ecosystems and groundwater sensitive areas.
- A reduction in groundwater levels and flows, and off-site discharge of water containing sediment from dewatering activities.
- Interception and interference with an aquifer that could obstruct groundwater flow and limit groundwater availability.
- Contamination of soils, and surface and groundwater from accidental spills or oil leaks. This might include grease or fuel from machinery and vehicles, construction sites or

compounds, or spills of other chemicals that may be used during the course of construction.

- Disturbance of unidentified contaminated land eg former cattle tick dip sites, or other pesticide/chemical concentrations in soil from historical land use practices, and subsequent generation of contaminated runoff.

Some impacts on soil and water attributable to the Project are anticipated. Relevant aspects and the potential for related impacts have been considered in a risk assessment at Section 3.4 and Appendix A2 of the CEMP. Chapter 6 provides a suite of mitigation measures that will be implemented to avoid or minimise those impacts.

6 Environmental control measures

A range of environmental requirements and control measures are identified in the various environmental documents, including the EIS, supplementary assessments, Conditions of Approval and RMS documents, and from recent experience on similar road projects. Specific measures and requirements to address impacts on soil and water are outlined in Table 6-1.

Table 6-1 Soil and water management and mitigation measures

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
GENERAL					
SW1	Training will be provided to all project personnel, including relevant sub-contractors on sound erosion and sediment control practices and the requirements from this plan through inductions, toolboxes and targeted training.	Project inductions, training resources	Pre-construction/ Construction	Construction Manager/ Environmental Site Representative	G38/G36, Good practice
SW2	A Project Soil Conservationist will be engaged during detailed design to develop an erosion and sedimentation management report to inform the soils and water management plan and will be regularly consulted throughout construction to provide advice on erosion and sediment control design, installation and maintenance.	Soil conservationist	Pre-construction/ Construction	Environmental Site Representative	G38, Good practice, Submissions/PIR (SSW5)
SW3	An environmental protection scheduled activity licence will be obtained for the Project. All relevant conditions relating to soil and water management will be implemented as required by the licence.		Construction / Post construction	Construction Manager	POEO Act 1997
PROCEDURES AND PLANS					
SW4	Erosion and Sediment Control Plans (ESCPs) will be prepared and implemented in advance of construction, including earthworks and stockpiling. ESCPs will be updated as required.	ESC materials and equipment to install	Pre-construction/ Construction	Environmental Site Representative/ Foreman	Managing Urban Stormwater: Soils and Construction Volume 1 and Volume 2D, EIS (SSW4)
SW5	The following EWMS will be prepared and implemented to manage soil and water impacts. EWMS for activities identified as having high environmental risk will undergo a period of consultation with EPA and DPI Fisheries Conservation and		Construction	Superintendent/ Environmental Site Representative	G36 and G40

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	Aquaculture. Those marked with an asterisk below are those likely to be subject to consultation: • Activities that impact on environmentally sensitive areas*. • Sediment basin construction and maintenance*. • Management of Acid Sulfate Materials*. • Dewatering*. • Managing tannin leachate*. • Vegetation clearing and grubbing*. • Topsoil stripping*. • Underboring of waterways*				
SW6	All ASS or PASS disturbed during the construction process will be managed in accordance with RMS Acid Sulfate Soil Management Procedure (incorporating an Acid Sulfate Soils contingency plan as required under CoA D26(c)v) attached at Appendix C. The requirements will be incorporated into the EWMS for "Management of Acid Sulfate Materials" referred to in SW5.	App B11 CASSMP	Pre-construction / Construction	Superintendent / Environmental Site Representative	Submissions / PIR (SSW25) CoA D26(c) v
SW7	The requirements of the spoil and fill management procedure attached at Appendix B will be implemented throughout construction. The plan includes, among other detail, the types of material expected to be encountered during construction, and how excavated material will be handled, transported, stockpiled, reused and disposed.	Spoil and Fill Management Procedure (App B)	Construction	Superintendent/ Foreman	CoA D25(d)ix
SW8	Dewatering will be undertaken and managed in accordance with the Pacific Highway Projects Dewatering Guidelines attached at Appendix G. A specific EWMS for dewatering will be prepared and will consider and/or incorporate the following detail: • Areas of the site that will require dewatering. • Dewatering methods that will minimise potential environmental impacts.	Dewatering Practice Note (App G)	Construction	Superintendent/ Environmental Site Representative	G38 (Section3.5)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	• Opportunities for reuse. • The limitations for any proposed reuse methods. • Discharge locations and adequate energy dissipation. • Water quality criteria for discharge and/or reuse. • Treatment techniques required to meet the water quality criteria. • Water sampling and testing requirements. • Disposal of contaminated water				
SOIL EROSION AND SEDIMENTATION CONTROL					
SW9	Appropriate erosion and sediment controls, following the guidelines of the 'Blue Books' (Landcom, 2004 and DECC, 2008), will be established before the start of construction and maintained in effective working order for the duration of the construction period until site stabilisation. Specific controls will include: • Sediment fences and filters to intercept and filter small volumes of non-concentrated construction runoff • Rock check dams across swales and diversion channels to reduce the velocity of flow, thereby reducing erosion of the channel bed and trapping sediment. • Level spreaders to convert erosive, concentrated flow into sheet flow. • Diversion drains that collect construction runoff and direct it away from unstable and/or exposed soil to treatment facilities. • Diversion drains to collect clean runoff from upstream of the construction area and divert it around or through the site without it mixing with construction runoff. • Lining of channels and other concentrated flow paths.	ESC materials and equipment to install, Blue Book, RMS' Technical Guideline – Temporary Stormwater Drainage for Main Road Construction	Construction	Superintendent/ Foreman/ Environmental Site Representative	CoA B34 Submissions/PIR (SSW26)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	• Sedimentation basins to capture sediment and associated pollutants in construction runoff (see further details below). Specific measures and procedures for works within waterways, such as the use of silt barriers and temporary creek diversions, in accordance with RMS' Technical Guideline – Temporary Stormwater Drainage for Main Road Construction (RMS, 2011).				
SW10	Erosion and sediment control plans will be developed in line with current Roads and Maritime specifications and as detailed in the Working paper – Water quality.	G36, G38, Working paper – Water quality	Pre-construction and construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW4)
SW11	Sedimentation basins and water quality ponds will be sized and located in accordance with the principles identified in the Working paper – Water quality.	Working paper – Water quality	Pre-construction and construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW6)
SW12	Exposed areas will be progressively rehabilitated. Methods will include permanent revegetation, or temporary protection with spray mulching or cover crops.	ESC materials and equipment to install	Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW7)
SW13	The project site will be inspected for weed seedlings at six monthly intervals and controlled with herbicide as required		Construction	Environmental Site Representative/ Superintendent/ Foreman	G38
SW14	Any necessary approvals will be obtained in accordance with Roads and Maritime specification G36 for permanent and temporary waterway crossings.	G36	Construction	Environmental Site Representative/	Submissions/PIR (SSW8)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
				Superintendent/ Foreman	
SW15	All work potentially affecting wetlands will be undertaken in consideration of the requirements outlined in the NSW Wetlands Management Policy 2010.	NSW Wetlands Management Policy 2010	Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW9)
SW16	The design and construction of works within riparian corridors and within the minimum required distance from waterways will be undertaken in accordance with NSW Office of Water guidelines for working within riparian corridors.	NSW Office of Water guidelines for working within riparian corridors	Pre-construction/ Construction	Superintendent/ Foreman/ Environmental Site Representative	EIS (SSW36)
SW17	In steep areas, the length between sediment fences and other physical controls will be decreased to reduce soil erosion.		Construction	Superintendent/ Foreman/ Soil Conservationist	EIS (SSW38)
SW18	Construction sequencing and temporary diversions of water will be developed and designed to consider the impact of change on flow regimes and to minimise these changes throughout construction.		Pre-construction/ Construction	Superintendent/ Foreman/ Soil Conservationist	EIS (SSW39)
SW19	Works will be programmed to minimise the extent and duration of disturbance to vegetation. This will include leaving clearing (undertaken by manual means) and initial earthworks in intermittent and permanent watercourses until subsequent works are about to commence.		Pre-construction/ Construction	Superintendent/ Foreman	G38

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
SW20	Wastewater or “dirty” water generated during the construction process will, wherever possible, be collected, treated and disposed of by appropriate means, including the installation of sediment barriers downslope of all disturbed areas. In areas where it is not possible to direct dirty water to sediment basins, other sediment controls will be implemented in accordance with “Blue book” best practice.		Construction	Superintendent/ Foreman	G38
SW21	Clean and dirty water runoff will be adequately separated to avoid mixing where possible through the use of diversions, clean water drains, and the early installation of permanent drainage infrastructure.		Construction	Superintendent/ Foreman	G38
SW22	Active work areas will be stabilised at the end of each day’s work and/or just prior to inclement weather, by means such as grading or smooth drum rolling to create a smooth surface and by installing of temporary “catch” drains to prevent/minimise transport of sediment.		Construction	Superintendent/ Foreman	G38
SW23	Catch drains, contour and diversion drains across exposed areas will be installed immediately following clearing, and re-established and maintained during topsoil removal and earthwork operations.		Construction	Superintendent/ Foreman	G38
SW24	Coarse aggregate, rumble grids or similar will be provided at exit points from construction areas onto public roads to minimise the tracking of soil and particulates onto public roads.		Pre-construction/ Construction	Superintendent/ Foreman	G38
SW25	Vehicle movements from site will be minimised during wet weather if the tracking of mud may become an issue.		Pre-construction/ Construction	Superintendent/ Foreman	Good practice
SW26	Clean up of mud spilt or spread by construction equipment, loose rock, soil, debris etc from public roads or other sealed pavements will be initiated immediately.		Pre-construction/ Construction	Superintendent/ Foreman	G36, G38

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
SW27	All required sediment basins and associated drainage will be installed and commissioned prior to the commencement of clearing and grubbing works in that catchment that could cause sediment to leave site. (Except where clearing is required for basin installation.)		Construction	Superintendent/ Foreman	Good practice
SW28	Sediment basins will be operated and maintained in accordance with the Sediment Basin Management and Discharge Procedure and Water Quality Monitoring Program contained in Appendix H and Appendix A, respectively. Basins will not be discharged until all monitoring and water quality criteria has been verified and documented.	Sediment Basin Management and Discharge Procedure (App H), Water Quality Monitoring Program (App A)	Construction	Superintendent/ Foreman	Good practice
SW29	Works within waterways will consider the need to maintain fish passage, in consultation with the Department of Primary Industries (Fisheries).		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW27)
CONSTRUCTION SEDIMENT BASINS					
SW30	In accordance with “blue book” best practice, sedimentation basins will be inspected at regular intervals and following significant rainfall events to assess available water storage capacity, water quality, structural integrity and debris levels.	Blue Books (Landcom, 2004)	Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW31)
SW31	Where appropriate, an approved flocculant will be applied to sedimentation basins as early as possible so that early mixing of flocculants occurs. Water quality in the sediment basin will be tested prior to discharge in accordance with EPL requirements and the receiving waters quality criteria as defined in the RMS	Flocculant, Dewatering Practice Note (App G)	Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW32)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	Dewatering Practice Note and detailed in the surface water quality results in the EIS.				
SW32	Where sediment has built up in a basin to a point where the total sediment storage zone has reached capacity, sediment will be removed and appropriately disposed of.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW33)
SW33	Water from sedimentation basins will be used for construction purposes, such as dust suppression, where feasible.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW34)
SW34	When sedimentation basins require pumping out rather than discharge via a flow outlet, the inlet to the suction hose would be suspended in such a manner that sediment deposited within the basin would not be discharged.	Pump / syphon	Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW35)
SW35	Records will be kept of water quality monitoring and erosion and sediment control inspections, including details of rain events, use of flocculants, discharge, sediment removal and dewatering activities.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW36)
ANCILLARY FACILITY AND STOCKPILE MANAGEMENT					
SW36	Stockpiles and ancillary facilities will be located to minimise erosion and in accordance with the criteria outlined in Appendix A3 of the CEMP and Appendix I of this plan.	Stockpile Management Protocol (App I)	Pre-construction/ Construction	Superintendent/ Foreman/ Environmental Site Representative	CoA D21, CoA D25(d)ix, G38, Submissions/PIR (SSW11 – SSW13)
SW37	Measures to be implemented to minimise impacts to surface and ground water quality include:		Construction	Environmental Site	Submissions/PIR (SSW37)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	• Bunded storage facilities for chemicals, with impermeable base (eg clay lined). • Bunded areas for refuelling and wash-down. • Locating storage areas away from areas of known near-surface groundwater supplies.			Representative/ Superintendent/ Foreman	
SW38	At ancillary facilities, management of runoff and spills will include: • Restricting vehicle movements to designated pathways where feasible. • Paving areas that will be exposed for extended periods, such as car parks and main access roads, where reasonable and feasible. • Diverting off-site runoff around sites where required. • Locating chemical or other hazardous material storage areas away from areas of known near-surface groundwater supplies and ensuring the storage areas have an impermeable base (eg clay lined).		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW38)
SW39	Soil and water management at borrow source sites will be in line with Volume 2E of the Blue Book which covers water management of mines and quarries.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW39)
SW40	Topsoil, earthworks and other excess spoil material will be stockpiled and managed in accordance with Roads and Maritime Stockpile Management Guidelines (Roads and Maritime, 2011a) and the “Management of Surplus Material” in Section 3.9 of the Submissions/PIR.	RMS Stockpile Management Guidelines	Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW10)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
SW41	Where reasonable and feasible, stockpiles will: • Not require removal of areas of native vegetation. • Be located outside of known areas of weed infestation. • Be located such that waterways and drainage lines are not directly or indirectly impacted.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW11)
SW42	Where practicable, stockpiles will be located away from areas subject to concentrated overland flow. Stockpiles located on a floodplain be finished and contoured so as to minimise loss of material in flood or rainfall events.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW12)
SW43	Topsoil will be stockpiled separately and inspected for weed seedlings, pest and diseases at six monthly intervals and controlled with herbicide as required. Pathogens (including Phytophthora and Myrtle Rust) shall be managed in accordance with procedures in the CEMP Appendix B2 – CFFMP.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW13)
SW44	All construction stockpiles will comply with the requirements of the *Protection of the Environment Operations Act 1997* and NSW Waste Avoidance and Resource Recovery Strategy 2007 for any waste activities that involve the generation, storage and/or disposal of waste and also consider the NSW Resource Recovery Exemptions as applying the storage of stockpiled material.	*Protection of the Environment Operations Act 1997,* NSW Waste Avoidance and Resource Recovery Strategy 2007	Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW14)
SW45	Stockpiles containing potential acid sulfate soils will be lined, bunded and covered in accordance with relevant guidelines.		Construction	Environmental Site Representative/ Superintendent / Foreman	Submissions / PIR (SSW15)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
SW46	Management of tannin leaching from vegetation mulch will be in accordance with Roads and Maritime' Environmental Direction – Management of Tannins from Vegetation Mulch (Roads and Maritime, 2012) (refer to Appendix D)	Management of Tannins from Vegetation Mulch (App D)	Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW16)
DRAINAGE AND WATERWAY					
SW47	Watercourse crossings shall be designed in consultation with the DPI (Fisheries NSW), EPA, NOW and DoE, and where feasible and reasonable, be consistent with the *Guidelines for Controlled Activities Watercourse Crossings* (Department of Water and Energy, February 2008), *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge, 2003), *Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries, February 2004), and *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries, 2013). Where multiple cell culverts are proposed for crossings of fish habitat streams, at least one cell shall be provided for fish passage, with an invert or bed level that mimics watercourse flows. Where temporary crossings are required, these will be designed, constructed and maintained in accordance with *Managing Urban Stormwater Soils and Construction* Volumes 2A and 2D *Main Road Construction* (DECC 2008) and section 5.3.4 of the guideline *Managing Urban Stormwater 4th edition Volume 1 Soils and Construction* and subject to the preparation of an EWMS identified in SW2 and SW31. Temporary crossings will: • Be 'fish friendly' with a lower section of the temporary crossing provided to act as an emergency spillway. • Be used for the shortest time required to complete their designed operational function.	Blue Book, Guidelines for Controlled Activities Watercourse Crossings, Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings, Policy and Guidelines for Fish Friendly Waterway Crossings, Policy and Guidelines for Fish Habitat Conservation and Management	Construction	Environmental Site Representative/ Superintendent / Engineers	CoA B38 G36, PIR(B21)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	• Use material that will not result in fine sediment material entering the waterway. • Where rock crossings are used, the rock will be of suitable size to prevent / reduce the likelihood of the material being washed away in a storm or flood event, with large sized rock on the lower side of crossings where water velocity increases.				
SW48	Scour protection will be installed at the base of permanent and temporary drainage outlets, and will be integrated where feasible into current banks to minimise impacts.		Construction	Environmental Site Representative/ Superintendent/ Foreman	G36, G38
SW49	Drainage works will be stabilised against erosion by appropriate selection of channel dimensions, slope and lining, and the inclusion, if necessary, of drop structures and energy dissipaters.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Good practice
SW50	Culverts and permanent stream protection measures will be installed as early as possible in the construction program to facilitate transverse drainage during the early stages of construction.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Good practice
MANAGEMENT OF GROUNDWATER INTERSECTION					
SW51	Where groundwater is released, recharge of the water table is the preferred option of managing groundwater. This will be facilitated by collecting groundwater in grassed swales for infiltration back to the groundwater source. Where possible, these swales will divert the groundwater around the construction area so that the groundwater does not further mix with construction runoff.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW42)
SW52	If recharging is not possible or suitable, then discharging groundwater will be collected via the sedimentation basins before		Pre-construction	Environment Manage/	Submissions/PIR (SSW43)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	discharge into natural waterways. If discharging to downstream groundwater, then the potential effects of mounding will be mitigated.			Superintendent/ Foreman	
SW53	Dewatering of excavations will be undertaken in line with Roads and Maritime' Technical Guideline – Environmental Management of Construction Site Dewatering (Roads and Maritime, 2011c), and in accordance with any licence conditions.	RMS Technical Guideline – Environmental Management of Construction Site Dewatering	Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW44)
GROUNDWATER					
SW54	The proposed management strategy to address potential impacts at type A cuttings includes: • Pre-works investigations – geotechnical investigations to determine groundwater condition (quality parameters: electrical conductivity, groundwater depth, geological information), presence of actual or potential acid sulfate soils, presence or potential of salinisation, establishing groundwater monitoring sites, and gathering of other pertinent information. • Assessment – including the EIS assessment, the pre-works investigations carried out, groundwater modelling of cuts , and predictions made from those results. • Monitoring – to assess whether the investigation and its predictions are accurate and to instigate early intervention in the unlikely case/s that the actual outcomes deviate from predictions. Monitoring start before construction, and continue during construction. Monitoring also continue into the operation phase of the project. • Mitigation – implement environmental and engineering management measures where predictions and/or modelling and monitoring suggest that these are required to minimise impacts on groundwater.		Pre-construction and construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW46)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
SW55	The monitoring of locations in the vicinity of type B cuttings and major embankments will commence before construction to identify the need to implement any mitigation measure.		Pre-construction/ Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW47)
SW56	If required to manage groundwater impacts at type A and type B cuttings and major embankments, the following engineering mitigation measures will be considered: • Engineering measures that transfer the seepage water downstream. Standard practice will be to collect the seepage from the cut face in the drainage system for the highway, which will be diverted into water quality basins before being released back into the creek or natural drainage system at some point downstream. • Engineering impact mitigation measures that transfer the seepage water (where present) into the groundwater ecosystem immediately downslope of the cutting or embankments. The Tyndale and north/south of McIntyres Lane cuts are Type A cuts.		Pre-construction and construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW48)
SW57	Major embankments will be designed to enable distributed flow of surface waters.		Pre-construction and construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW49)
SW58	Sites used for batch plants, refuelling and chemical storage will be managed so that no groundwater intrusion occurs.		Pre-construction and construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW51)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
SW59	Implement mitigation measures contained in the Groundwater Management Strategy (RMS document).	Groundwater Management Strategy	Pre-construction/ Construction	Superintendent/ Environmental Site Representative	
WATER QUALITY AND USE					
SW60	Except as may be expressly provided by an EPL, the contractor shall comply with section 120 of the Protection of the Environment Operations Act 1997. Water will be used during construction for a number of purposes, including, but not limited to: • Dust control. • Washing of plant and equipment. • Drinking water. • Amenities. • Landscaping and re-vegetation. Prior to and during construction, water needs will be identified and water sources assessed to determine the most appropriate water source(s). When determining the most appropriate water source(s), the use of non-potable water sources will be considered in preference to potable water where appropriate. The water sources likely to be considered for construction include: • Creeks • Groundwater • Farm dams • Sediment basins. • Rainwater collection • Potable water		Construction	Environmental Site Representative/ Superintendent/ Foreman	CoA B30, Good practice

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	• Effluent reuse where available and meeting suitable standards. Appropriate licences and/or permits will be sought for each water source as required.				
SW61	Where available, and of appropriate chemical and biological quality, stormwater, recycled water or other water sources shall be used in preference to potable water for construction activities, including concrete mixing and dust control.		Construction		CoA B35
SW62	All surface water and groundwater shall be adequately treated as far as is practicable, prior to entering the stormwater system to protect the receiving water source quality.		Construction		CoA B36
MATERIAL STORAGE AND MANAGEMENT					
SW63	Concrete pumping or concreting activities will be undertaken in accordance with Environmental Best Management Practice Guideline for Concreting Contractors 2002 to prevent and/or minimise spillages.	Environmental Best Management Practice Guideline for Concreting Contractors	Construction	Superintendent/ Foreman	G38
SW64	Where no risk of contamination (surface or ground) exists, non-lined concrete washout points will be provided for washout of concrete trucks. These facilities will be located at least 50 metres away from natural and built drainage lines, unless approval is obtained from the Environmental Site Representative.		Construction	Superintendent/ Foreman	G38
SW65	An EWMS for managing tannin leachate (tannin leachate management protocol) will be prepared in accordance with the RMS Environmental Direction for the Management of Tannins from Vegetation Mulch attached at Appendix D. The requirements include detail on: • Planning and staging vegetation processing activities.	Management of Tannins from Vegetation Mulch (App D)	Construction	Environmental Site Representative/ Foreman	RMS Environmental Direction for the Management of Tannins from Vegetation Mulch CoA D26(c)vi

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	• Stockpile location and management to minimise the production and release of tannins. • Monitoring the stockpiles for the production of tannins. • Response to tannin production.				
SW66	Where refuelling on site is required, the following management practices will be implemented: • Refuelling will be undertaken on level ground and at least 20 metres from drainage lines, waterways and/or environmentally sensitive areas. • Refuelling will be undertaken within the designated refuelling areas with appropriate bunding and/or absorbent material. • Refuelling will not be undertaken on or in the vicinity vegetated areas (even roadside grasses). • Refuelling will be attended at all times. • Spill kits will be readily available and personnel trained in their use. A spill kit will be kept on the refuelling truck at all times. Hand tools will be refuelled within lined trays of site vehicles wherever possible.		Construction	Foreman	Good practice, G36
SW67	Physical controls to address the potential risks associated with the use and storage of chemicals on site will include: • Use of appropriately bunded storage facilities for chemicals and fuels. • Use of appropriately bunded areas for refuelling and washdown. • Availability of effective spill kits at all construction sites.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (SSW37)
SW68	An emergency spill response plan will be developed and incorporated into the soil and water management plan (refer to Appendix J). This plan will detail measures for the prevention,	Emergency Spill Response Plan (App J)	Construction	Environmental Site Representative/	Submissions/PIR (SSW22)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	containment and clean-up of accidental spills of fuels and chemicals.			Superintendent/ Foreman	
SW69	The storage, handling and use of the chemicals and fuels will be in accordance with the Work Health and Safety Act 2000 and Workcover's Storage and Handling of Dangerous Goods Code of Practice (WorkCover, 2005).	Work Health and Safety Act 2000, Workcover's Storage and Handling of Dangerous Goods Code of Practice	Construction	Environmental Site Representative/ Superintendent / Foreman	Submissions / PIR (SSW23)
ACID SULFATE SOILS					
SW70	All ASS or PASS disturbed during the construction process will be managed in accordance with RMS Acid Sulfate Soil Management Procedure attached at Appendix C. Specific controls to be implemented will include: • Capping of exposed surfaces with clean fill to prevent oxidation. • Placing excavated acid sulfate soils separately in a lined, bunded and covered area. • Neutralising acid sulfate soils for reuse (where appropriate) by using additives such as lime. • Disposing of acid sulfate soils where necessary in accordance with the relevant guidelines set out in DECC (2008). The requirements will be incorporated into the EWMS for "Management of Acid Sulfate Materials" referred to in SW6.	App B11 CASSMP	Construction	Foreman / Superintendent / Environmental Site Representative	EIS (SSW31, SSW32)
SW71	Strategies to remove / reduce risks associated with acid sulfate soils will be identified.		Pre-construction and Construction	Environmental Site Representative/	Submissions / PIR (SSW24)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
				Superintendent / Foreman	
SW72	An acid sulfate soils management plan will be implemented in accordance with Guidelines for the Management of Acid Sulfate Materials (Roads and Maritime 2005) and Waste Classification Guidelines Part 4: Acid Sulfate Soils (DECC 2008), where there is a probability of encountering acid sulfate soils during construction.	Guidelines for the Management of Acid Sulfate Materials, Waste Classification Guidelines Part 4: Acid Sulfate Soils	Construction	Environmental Site Representative/ Superintendent / Foreman	Submissions / PIR (SSW25)
REHABILITATION AND LANDSCAPING					
SW73	Disturbed areas will be progressively stabilised during the construction phase eg with a cover crop, hydromulch, hydroseeding, topsoil and/or mulch. Wherever possible, permanent landscaping and revegetation works will take place progressively.		Construction	Superintendent/ Foreman	G38, EIS (SSW7)
MONITORING					
SW74	Surface water quality monitoring will be undertaken in accordance with Roads and Maritime' Guideline for Construction Water quality Monitoring (RTA, 2003), and as per the framework outlined in the Working paper – Water quality.	RMS Guideline for Construction Water quality Monitoring, Working paper – Water quality	Pre-construction and Construction	RMS	Submissions / PIR (SSW62)
SW75	Groundwater monitoring will be undertaken in accordance with the framework outlined in the Working paper – Groundwater (Section 5.2).	Working paper – Groundwater	Pre-construction and Construction	RMS	Submissions / PIR (SSW63)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
SW76	Rainfall forecasts will be monitored daily and the site managed to avoid erosion and sedimentation, and to minimise the impact of heavy rainfall and flood events.		Construction	Superintendent/ Foreman/ Environmental Site Representative	G38
SW77	Erosion and sediment controls will be inspected at least daily (with maintenance and/or modifications made as necessary). Inspections and/or maintenance during wet weather may be increased where necessary.		Construction	Environmental Site Representative/ Superintendent / Foreman	Good practice
SW78	A project soil conservationist will inspect the work areas, typically on a fortnightly basis, or as required where high-risk activities are proposed, or where sensitive areas have the potential to be affected eg SEPP 14 wetland, heritage sites.	Soil conservationist	Pre-construction/ Construction	Soil Conservationist Environmental Site Representative	Good practice
SW79	Monitoring of sediment basin water quality will be undertaken in accordance with EPL requirements. See Sediment Basin Management and Discharge Procedure in Appendix H.	Sediment Basin Management and Discharge Procedure (App H)	Construction	Environmental Site Representative	Appendix H
RECORDS					
SW80	Records of dewatering activities will be maintained. Details will include: i. A copy of the work method statement(s). ii. Date, time and estimated volume released at each discharge location. iii. Water quality test results for each discharge. iv. The personnel approving the dewatering activities.		Construction	Environmental Site Representative	G38

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
	v. Evidence of discharge monitoring, or risk assessment and mitigation measures used to eliminate the risks of pollution.				
HYDROLOGY AND FLOODING					
SW81	Cane drain diversions will be designed and constructed in consultation with the relevant cane industry stakeholders and impacted landowners. This will consider the potential diversions detailed in the Working Paper – Hydrology and flooding and the additional assessment provided in Chapter 3 of the Submissions / Preferred Infrastructure Report.	Working Paper – Hydrology and flooding	Pre-construction and construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (HF3)
SW82	Waterway diversions will be designed in consultation with Office of Environment and Heritage, NSW Office of Water and Department of Primary Industries (Fisheries) so that the final diversion mimics, where feasible and reasonable, the characteristics of the waterway that is being diverted. Characteristics include flow regime, flow velocity, base material, vegetation and habitat for aquatic fauna.		Construction	Environmental Site Representative/ Superintendent / Foreman	Submissions / PIR (HF7)
SW83	Revegetation of waterway diversions and surrounding areas will be undertaken in accordance with the following principles: • Diversions will be stabilised prior to the diversion receiving flows, in conjunction with the establishment of other scour and erosion control measures. • Diversions will establish appropriate vegetation communities along the channel bed and banks, using endemic native species.		Construction	Environmental Site Representative/ Superintendent / Foreman	Submissions / PIR (HF8)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
SW84	The potential impacts of ancillary facilities and haul roads on cane drains are currently being investigated for the approved ancillary facility location. The design of these ancillary facilities will be developed in consultation with relevant cane industry stakeholders, affected landowners, and in accordance with the following principles: • Maintain conveyance characteristics of existing cane drains. • Provide adequate capacity in temporary drainage to prevent blockages.		Pre-construction and construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (HF15)
SW85	All work within 40 metres of a permanent watercourse, crossed by the project, will be undertaken in accordance with the NSW Office of Water ‘Guidelines for Controlled Actions' and industry best practice including maintaining where feasible and reasonable the geomorphic integrity and natural hydrological flow regime.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (HF19)
SW86	The design of temporary fencing at culvert and bridge crossings will consider the potential for blockage and be designed and operated in a manner that does not result in impacts on flooding.		Construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (HF20)
SW87	Hydrology and flood modelling of the ancillary facility at site number 4a has been undertaken to assess the potential flood impacts. The assessment concludes that the proposed ancillary facility would not have any adverse flood impacts when compares to the flood management objectives for the project.	Working Paper – Hydrology and flooding	Pre-construction	Construction Manager/ Environmental Site Representative	Submissions/PIR (HF22)
SW88	Consultation with affected landowners will be undertaken during detailed design and construction regarding flooding impacts on properties, residences and other structures.		Pre-construction and construction	Environmental Site Representative/ Superintendent/ Foreman	Submissions/PIR (HF30)

ID	Measure/requirement	Resources needed	When to implement	Responsibility	Reference
SW89	The contractor shall provide feasible and reasonable assistance to the relevant council and/or NSW State Emergency Service, to prepare any new or necessary update(s) to the relevant plans and documents in relation to flooding, to reflect changes in flooding levels, flows and characteristics as a result of the SSI.		Pre-construction and construction	RMS	CoA D16

7 Compliance management

7.1 Roles and responsibilities

The Project Team's organisational structure and overall roles and responsibilities are outlined in *Section 4.2 of the CEMP*. Specific responsibilities for the implementation of environmental controls are detailed in Section 6 of this Plan.

7.2 Training

All employees, contractors and utility staff working on site will undergo site induction training relating to soil and water management issues. The induction training will address elements related to soil and water management including:

- Existence and requirements of this sub-plan.
- Relevant legislation.
- Roles and responsibilities for soil and water management.
- The location of ASS or PASS.
- Water quality management and protection measures.
- Procedure to be implemented in the event of an unexpected discovery of contaminated land.

Targeted training in the form of toolbox talks or specific training will also be provided to personnel with a key role in soil and water management. Examples of training topics include:

- Practical one day training course on "Bluebook Volume 2D" as applicable to the project.
- ERSED control installation methodology.
- Sediment basin construction.
- Sediment basin operation.
- Sediment basin maintenance.
- Working near or in drainage lines and creeks.
- Emergency response measures in high rainfall events/Pollution Incident Response Management Plan (PIRMP).
- Preparedness for high rainfall events.
- Lessons learnt from incidents and other event eg high rainfall/flooding.
- Mulch and tannin management.
- Spill response
- Stockpile location criteria.

The soil conservationist will assist with project training in regards to erosion and sediment control issues. Further details regarding staff induction and training are outlined in *Section 5 of the CEMP*.

7.3 Monitoring and inspection

Regular monitoring and inspections will be undertaken in the lead up to, during and following construction. Monitoring and inspections will include, but not be limited to:

- daily records of rainfall, measured at the same time each day.
- Weekly and post rainfall inspections to evaluate the effectiveness of erosion and sediment controls measures in accordance with *Section 8.1.1 of the CEMP*. Post rainfall inspections are to be undertaken within 3 hours of the start of rainfall that causes runoff to occur (during normal work hours) or within 24 hours (outside normal working hours). Inspections to include:
    - disturbed areas and revegetated / stabilised areas, permanent and temporary erosion and sediment control works, check dams and sediment fences plus stormwater entry points such as pits and inlets, stockpile sites.
- Construction sediment basin water quality prior to discharge.
- All monitoring will be carried out in accordance with AS 5667.1 1987.

Additional requirements and responsibilities in relation to inspections are documented in *Section 8.2 of the CEMP*.

7.4 Licenses and permits

An Environment Protection License (EPL) will be obtained for the Project. The EPL typically prescribes water quality parameters to be measured and associated discharge criteria. They also detail the monitoring and analytical requirements by reference to authority publications eg Approved Methods for Sampling and Analysis of Water Pollutants in NSW, 2004. Typical water quality discharge criteria are listed in Table 7-1

Table 7-1 Discharge water quality criteria

Parameter	Criteria	Sampling method	Analytical method
pH*	6.5 –8.5	Probe or Grab Sample	Field analysis and confirmed as required with laboratory assessment
Total Suspended Solids*	50 mg/L	Grab Sample	Laboratory analysis
Oil and Grease*	No visible	Grab Sample	Field analysis and confirmed as required with laboratory assessment

Any other relevant licenses or permits will be obtained in the lead up to and during construction as required.

7.5 Weather monitoring

Rainfall at the premises will be measured and recorded in millimetres per 24-hour period at the same time each day from the time that the site office associated with the activities is established. Automatic rainfall intensity/ weather devices will be installed on the Project, likely to be at the major compounds. The data collected from the automatic weather stations shall:

- Provide a more detailed early understanding of potential rainfall and other adverse weather impacts.

- Provide a proactive and early inspection and maintenance regime response to erosion and sedimentation and the effects of other adverse climatic conditions before pollution occurs.
- Trigger weather alarms and messages to relevant site personnel to take action where appropriate.
- Assess and validate the performance of installed erosion and sediment control measures against the design performance criteria.
- Provide compliance data for statutory monitoring on-site.

The stations will be sited by a suitably qualified individual in accordance with Bureau of Meteorology Observation Specification No. 2013.1 and will advise on the weather parameters required to be measured. The rain gauge within each mobile automatic weather station shall be of the tipping bucket type. The stations shall have a battery or voltage meter and shall target 98% reliability. Manual rain gauges will also be used across the project to assist with assessment of rainfall data accuracy. The weather stations shall conform to relevant standards for the location of such devices and shall be fully protected and secured.

Data from the automatic weather stations shall be accessible via SMS alarms or queries to a mobile phone and downloadable to a desktop console logger or laptop computer. SMS queries and alarms shall be sent to RMS Representatives as necessary. All data shall be accessible at all times by the RMS representative(s). The mobile automatic weather stations shall download data to the internet and allow live views of weather data by authorised users, which shall include RMS Representative(s), the Project Verifier and the Environmental Representative.

In accordance with normal standard construction practices weather forecasts shall be used to guide work activities undertaken on-site. Forecasts shall be checked at the start of each day and prior to undertaking new work activities that may be affected by rainfall or adverse weather. Where weather forecasts predict conditions that may pose an environmental risk, site environmental controls shall be inspected and secured to reduce erosion and sediment control impacts. Contingency planning to prevent spills shall also involve monitoring for predicted flood events and the removal of fuels and chemicals from flood prone areas.

7.6 Auditing

Audits (both internal and external) will be undertaken to assess the effectiveness of environmental controls, compliance with this plan, CoA and other relevant approvals, licenses and guidelines.

Audit requirements are detailed in *Section 8.3 of the CEMP*.

7.7 Reporting

Reporting requirements and responsibilities are documented in *Sections 8.3 and 8.5 of the CEMP*.

8 Review and improvement

8.1 Continuous improvement

Continuous improvement of this Plan will be achieved by the ongoing evaluation of environmental management performance against environmental policies, objectives and targets for the purpose of identifying opportunities for improvement.

The continuous improvement process will be designed to:

- Identify areas of opportunity for improvement of environmental management and performance.
- Determine the cause or causes of non-conformances and deficiencies.
- Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies.
- Verify the effectiveness of the corrective and preventative actions.
- Document any changes in procedures resulting from process improvement.
- Make comparisons with objectives and targets.

8.2 CSWQMP update and amendment

The processes described in *Section 8 and Section 9 of the CEMP* may result in the need to update or revise this Plan. This will occur as needed.

Any revisions to the CSWQMP will be in accordance with the process outlined in *Section 1.6 of the CEMP*. This plan the ESCP and Stockpile Management Plan shall be revised when erosion/sedimentation control measures, stabilisation control measures and other soil and water control measures are found to be not fully effective, including review of design parameters used for BLUE BOOK calculations.

The Environmental Representative is able to approve minor amendments to the CSWQMP in accordance with CoA D23 (e). All other amendments have to be approved by the Secretary.

A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure – refer to *Section 10.2 of the CEMP*.

Appendix A
Water Quality Monitoring Program

Pacific Highway Upgrade – Woolgoolga to Ballina Sections 3 to 11

Water Quality Monitoring Program

quality solutions **sustainable** future

Pacific Highway Upgrade – Woolgoolga to Ballina Sections 3 to 11

Water Quality Monitoring Program

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2476-1009	Third Issue	25/06/2015	Tim Ruge
2476-1010	Fourth Issue	01/07/2015	Tim Ruge

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Introduction

This Water Quality Monitoring Program (WQMP) outlines monitoring requirements for surface waters and groundwater for the construction and post-construction phases of Sections 3-11 of the Woolgoolga to Ballina Pacific Highway Upgrade. There are 40 surface water locations (77 sampling sites) and 132 groundwater monitoring bores spread over the 124.5 kilometres of upgrade works.

Source: Woolgoolga to Ballina. Upgrading the Pacific Highway. Project Summary (RMS, 2012)

Figure 1.1 Overview of Sections 3-11 of the W2B Pacific Highway Upgrade

1.1 Objectives

The objective of the WQMP is to monitor and manage the construction and operation impacts of the highway upgrade on surface water bodies and groundwater resources.

The key surface water quality objective of the overall Woolgoolga to Ballina (W2B) Pacific Highway Upgrade Program is to protect downstream environments from the potential impacts of surface runoff during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012c:58). Similarly, the key groundwater objectives of the W2B project are to protect environmental receivers of groundwater flows, and groundwater users from the potential impacts on groundwater levels and quality during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012d:10).

The WQMP will play a crucial role in ensuring construction and operation of the W2B project does not have a negative impact on sensitive receiving environments such as Marine Parks, SEPP14 wetlands, threatened species habitat, drinking water catchments, or endangered ecological communities.

The outcomes of the WQMP will assist with achieving water quality and hydrology related management objectives for the W2B project including:

- mitigating impacts to surface water quality in order to protect aquatic ecology and ecosystem characteristics in adjacent catchments; and
- mitigating impacts to groundwater hydrology in order to protect licensed bores and dams, water bodies and groundwater dependant ecosystems.

1.2 Minister's Conditions of Approval

The Minister's Conditions of Approval (MCoA) granted by the Minister for Planning on 24 June 2014 for the Woolgoolga to Ballina Pacific Highway Upgrade includes the following Condition D12 with respect to Soil, Water Quality and Hydrology.

> D12. The Applicant shall prepare and implement a **Water Quality Monitoring Program** to monitor the construction and operation impacts of the SSI on surface and groundwater quality and resources and wetlands, prior to construction. The Program shall be prepared in consultation with the EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields), to the satisfaction of the Secretary, and shall include but not necessarily be limited to [the items in **Table 1.1**].

Table 1.2 MCoA Requirements for the Water Quality Monitoring Program

Item	*Details*	*Addressed in*
a)	identification of surface and groundwater quality monitoring locations (including watercourses, waterbodies and SEPP14 wetlands) which are representative of the potential extent of impacts from the SSI.	Section 2
b)	the results of any groundwater modelling undertaken.	Section 3 and Appendices B to J
c)	identification of works and activities during construction and operation of the SSI, including emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and known Oxleyan Pygmy Perch habitat.	Section 1.3, 1.4 and 1.5
d)	development and presentation of parameters and standards against which any changes to water quality will be assessed, having regard to the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (Australian and New Zealand Environment Conservation Council, 2000) or relevant baseline data.	Section 7

Item	Details	Addressed in
e)	representative background monitoring of surface and groundwater quality parameters for a minimum of twelve months (considering seasonality) prior to the commencement of construction, to establish baseline water conditions, unless otherwise agreed by the Secretary.	Section 3 and Appendices B to J
f)	a minimum monitoring period of three years following the completion of construction or until the affected waterways and/or groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition. The monitoring shall also confirm the establishment of operational water control measures (such as sedimentation basins and vegetation swales).	Section 4
g)	contingency and ameliorative measures in the event that adverse impacts to water quality are identified.	Section 8
h)	reporting of the monitoring results to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields).	Section 7.5

Consultation with the government authorities is detailed in **Appendix XX** of this WQMP. **[to be added to final document following consultation with authorities]** In accordance with the Staging Report submitted for the project, the Water Quality Monitoring Program for the Woolgoolga to Glenugie section of the project was submitted to the Department and approved on 8 May 2015. This report addresses the requirements of the remaining sections of the project.

1.3 Risk to Surface Waters

The following provides background information regarding the general risks to surface waters posed by the highway upgrade. The information is largely based on the environmental impact statement documents for the Woolgoolga to Ballina highway upgrade.

1.3.1 Construction Stage

During construction, the highest risk of impacts on water quality would be associated with:

- Exposure of soils during earthworks (including stripping of topsoil, excavation, stockpiling and materials transport), which may result in soil erosion and off-site movement of eroded sediments by wind and/or stormwater to receiving waterways, resulting in increased nutrients, metals and other pollutants.
- Accidental leaks or spills of chemicals, fuels, oils and/or greases from construction plant and machinery, which may result in pollution of receiving waterways.
- Exposure of acid sulfate soils (as a result of earthworks or dewatering), which may result in generation of sulfuric acid and subsequent acidification of waterways and mobilisation of heavy metals in the environment.
- Disturbance of contaminated land causing contamination of downstream waterways, impacting on aquatic and riparian habitats.
- Removal of riparian vegetation, which may result in soil and stream bank erosion and increased sediment loads in nearby creeks.
- Direct disturbance of waterway beds and banks during culvert and bridge construction and temporary or permanent creek diversions, which may lead to high volumes of sediment entering and polluting the waterways.
- Changes to flow regimes, which can change the volumes and flow rates of water, leading to stagnation of a waterway and changes in turbidity, nitrogen and phosphorus levels. Reduction in flow regimes also has the potential to expose potential acid sulfate soils if it results in a reduction to groundwater levels.
- Leaching of tannins from stockpiles of cleared vegetation, which may have a number of adverse effects on receiving waters, including:

- Increased biological oxygen demand, with consequent decreases in dissolved oxygen
- Reduced water clarity and light penetration
- Decreased pH.

- Increase in pH from concreting and lime stabilisation works.
- Pollution by hydrocarbons during or following sealing or asphalting works.

During construction and operation, changes to water velocities and disturbance to riparian and instream habitats have the potential impact on successful fish passage. This is relevant to both permanent waterway crossings (such as bridges and culverts), as well as temporary waterway crossings (such as causeways, fords). Short term impacts include localised disturbance to riparian and instream habitats such as increased sedimentation and shading (RMS, Aurecon, SKM, 2012e:388).

1.3.2 Operational Stage

Once the highway upgrade is operating, there would be potential for impacts on soils, water quality and groundwater. However, the likelihood and severity of these potential impacts would be minimised by incorporating management and mitigation measures into the design of the highway upgrade, as described in **Section 8**. These measures would protect soils, receiving waters and groundwater.

During operation, the main potential impact on water quality would be associated with runoff from stormwater and direct deposition of airborne particles, causing acute or chronic contamination of water quality in downstream waterways that receive discharged stormwater during rainfall events.

Pollutants from stormwater runoff include sediments, hydrocarbons, metals, and microbials. These deposits build up on road surfaces and pavement areas (including rest areas and truck checking stations) during dry weather and get washed off and transported to downstream waterways when it rains. Other pollutants in the atmosphere, derived from local and regional sources, would also be deposited and build up on the widened road pavement and contribute to impacts on water quality.

In addition, accidental spills of petroleum, chemicals and hazardous materials as a result of vehicle leaks or accidents, and waste discarded by motorists, could pollute downstream waterways and groundwater sources.

The potential impacts of reduced water quality on sensitive receiving environments have also been considered. Because the project includes design measures to minimise the likelihood of impacts on water quality, operation of the project would be unlikely to have an adverse impact on sensitive receiving environments and high risk areas.

As noted in **Section 1.3.1**, changes to water velocities and disturbance to riparian and instream habitats have the potential impact on successful fish passage at permanent waterway crossings (such as bridges and culverts). Long term impacts include the impediment of fish movements within their natural range, habitat changes or pollution (RMS, Aurecon, SKM, 2012e:388).

1.4 Risk to Groundwater

This section provides background information regarding the general risks to groundwater posed by the highway upgrade. The information is largely based on the environmental impact statement documents for the Woolgoolga to Ballina highway upgrade.

1.4.1 Construction Stage

The main risks to groundwater during construction of the project would be from:

- Changes in surface flows, groundwater flow regimes and 'draw down' of the water table as a result of intersection of groundwater by cuttings and subsequent groundwater discharge.
- Groundwater contamination, which may occur if construction activities are not adequately managed, particularly in areas of shallow groundwater.

1.4.1.1 Risks to Groundwater from Cuttings

Localised draw down of the groundwater table can occur around cutting sites where the design profile of the proposed highway cuttings is below the level of the groundwater table. This may impact on groundwater flow to local creeks, streams, springs, local water resources and Groundwater Dependent Ecosystems (refer to **Section 1.5**).

1.4.1.2 Risks to Groundwater Quality from Surface Water

The potential risks to groundwater quality during construction would include contamination by hydrocarbons from accidental fuel and chemical spills, refuelling or through storage facilities, and contamination by contaminants contained in turbid runoff from unpaved surfaces.

In addition, site runoff can infiltrate groundwater sources. The process of infiltration is generally effective in filtering polluting particles and sediment. Hence, the risk of contamination to groundwater from any pollutants bound in particulate form in surface water, such as heavy metals, is generally low. Similarly, low-density pollutants such as insoluble hydrocarbons (oils, tars and petroleum products) would be preferentially retained in the soil profile and would not penetrate to the groundwater table. However, soluble pollutants, such as acids and alkalis, salts and nitrates, and soluble hydrocarbons, would be able to infiltrate through soils into the groundwater source and would pose a risk to that groundwater source. Under certain pH conditions, metals may also become soluble and infiltrate groundwater. In these areas, chemical treatments may be necessary. There is potential for long-term contamination risk to groundwater sources from the long-term accumulation of contaminants in the upper soil profile.

1.4.2 Operational Stage

The main hazard to groundwater quality during the operational phase would be pollutant runoff from the road surface infiltrating groundwater. The risks of groundwater pollution depend on the depth to groundwater and the permeability of the soils and geology that overlay groundwater reservoirs. Where groundwater is shallow or not protected from direct infiltration, the risks of pollution would vary depending on the nature of the pollutants of concern. The process of infiltration is generally effective in removing insoluble substances and contaminants that are readily bound to sediment particles, including heavy metals and hydrocarbons like oils, tars and petroleum. Therefore, runoff or spills of these substances have a relatively low risk of causing groundwater contamination. In contrast, soluble pollutants, such as acids, alkalis, salts and nitrates are less readily removed by the infiltration process and have a greater chance of reaching groundwater.

In areas where cuttings penetrate water tables, ongoing seepage would occur unless measures are put in place. Cuttings in areas of naturally high groundwater would see a reduced risk over time as groundwater pressures relax and re-equilibrate under the elevated discharge regime. In areas cut into rocks of low permeability (such as fractured rocks and porous sediments), the risk would remain high as groundwater pressures would not relax and seepage may continue throughout the life of the road.

1.5 Risk to Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) occur in nearly all sections of the W2B upgrade. GDE's include ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater.

The Woolgoolga to Ballina – Pacific Highway Upgrade Environmental Impact Statement (EIS) documents identify several vegetation communities and habitats as GDEs which comprise vegetation occurring on waterways and floodplains which are reliant on groundwater. They include:

- Freshwater wetlands;
- Sub-tropical coastal floodplain forest;
- Swamp sclerophyll forest;
- Swamp oak floodplain forest; and

- Lowland rainforest.

Construction of the W2B upgrade may potentially impact on these GDEs by blocking or altering subsurface flows and drainage paths. Development associated with future highway construction has the potential to affect GDEs function and viability by alteration of surface and subsurface conditions which are outside the physiological tolerance range or dispersal capabilities of groundwater reliant communities (Serov *et al* 2012 cited in Coffey Geotechnics 2014).

Potential impacts to GDEs may include changes in groundwater reliant communities due to changes in local water tables from over extraction or drainage, exposure and subsequent oxidation of potential acid sulfate soils, and resulting changes to groundwater and surface water quality or from saline intrusion. Potential impacts on groundwater recharge rates from highway construction have been assessed in the EIS to be generally greatest in areas where significant road cuttings are required as excavations may potentially intersect the water table and affect groundwater levels downstream (RMS, Aurecon, SKM, 2012a).

2

Monitoring Locations

There are 40 surface water monitoring locations including groundwater dependent ecosystems. Most locations include an upstream and downstream sampling site resulting in a total of 77 sampling sites. The sampling sites are listed in **Table 2.1** and mapped in **Appendix A**.

There are 132 groundwater bores monitoring significant cuts and fill embankments. Groundwater levels will be monitored at each bore, and water quality will be monitored at 62 of the 132 bores. The water quality sites have been selected for sites close to sensitive receiving environments or contaminated sites, and to provide an even spread along the works. The monitoring bores are listed in **Table 2.2** and mapped in **Appendix A**.

2.1 Surface Water Monitoring Locations

The objective of the surface water monitoring is to assess potential impacts of the highway upgrade on water quality and its beneficial uses. These beneficial uses can include: protect aquatic ecosystems; agricultural uses including stock watering; recreational uses; and drinking water supplies.

The selected waterways are generally the same as the monitoring sites from the pre-construction monitoring phase but with the addition of an upstream or downstream monitoring site. However, the pre-construction monitoring locations GDE04 and GDE05 (Sections 8) have not been selected due to them being ponds that will be filled as they located directly in the footprint of the proposed highway upgrade. The selected waterways are associated with sensitive receiving environments, groundwater dependent ecosystems (GDE's) and Oxleyan Pygmy Perch habitat. Refer to **Appendices B to J** for the respective highway sections (3 to 11) for descriptions of the sensitive receiving environments associated with the nominated monitoring locations.

The pre-construction sampling locations at each waterway were generally located on the downstream side of the proposed highway alignment at a location near the project boundary. The proposed sampling locations for the construction and post-construction phases are generally located both upstream and downstream of the highway alignment, within proximity to the pre-construction sampling locations. This has been done to allow for a direct comparison between upstream and downstream conditions as well as a comparison with pre-construction monitoring results.

Table 2.1 Surface Water Monitoring Point Locations

Highway Section	*Waterway*	*Site Identifier*	*Identifier from Pre-Const'n*	*Approx. Chainage*	*Easting*	*Northing*
Section 3 - Glenugie to Tyndale	Picanny Creek / Pheasant Creek	SW3-01	SW01	35700	502919	6704727
		SW3-02	SW02	36300	503180	6705319
	Unnamed tributary Glenugie Creek	SW3-03	SW03	36900	504445	6708191
		SW3-04			504358	6708281
	Coldstream River	SW3-05	SW04	42400	507255	6708458
		SW3-06			507329	6708595
	Coldstream River	SW3-07	SW05	43350	507910	6708618
		SW3-08			507954	6708752

Highway Section	*Waterway*	*Site Identifier*	*Identifier from Pre-Const'n*	*Approx. Chainage*	*Easting*	*Northing*
	Pillar Valley Creek	SW3-09	SW06	46400	510893	6709592
		SW3-10			510879	6709771
	Black Snake Creek	SW3-11	SW07	46600	511113	6709869
		SW3-12			510979	6709887
	Unnamed Creek tributary of Ellis Swamp	SW3-13	SW22	50400	512238	6713228
		SW3-14			512152	6713216
	Chaffin Creek	SW3-15	SW08	52450	512152	6715309
		SW3-16			512062	6715349
	Unnamed tributary of Chaffin Creek	SW3-17	SW09	54700	512749	6717380
		SW3-18			512694	6717497
	Chaffin Creek	SW3-19	SW10	57100	513202	6719731
		SW3-20			513083	6719842
	Unnamed bodies of water	SW3-21	SW11	58700	513775	6721320
		SW3-22			513632	6721333
	South Arm Clarence River	SW3-23	SW12	67950	514434	6730050
Section 4 - Tyndale to Maclean	Shark Swamp Overflow	SW4-01	SW23	73400	518903	6732813
		SW4-02			518114	6732934
	Shark Creek	SW4-03	SW13	74950	519207	6734318
		SW4-04			519109	6734316
	Edwards Creek	SW4-05	SW14	80200	520044	6739410
		SW4-06			519987	6739420
Section 5 - Maclean to Iluka Road	Yaegl Wetland	SW5-01	SW24	84400	522372	6742684
		SW5-02			522718	6742860
	Unnamed tributary of James Creek	SW5-03	SW15	85100	523030	6743026
		SW5-04			523183	6743066
	Clarence River	SW5-05	SW16	86300	523341	6744054
		SW5-06			523547	6744075
	Serpentine Channel	SW5-07	SW17	89350	523513	6747097
		SW5-08			523598	6747096
	North Arm (Clarence River)	SW5-09	SW18	94200	524306	6751477
		SW5-10			524438	6751489
	Mororo Creek (South)	SW5-11	SW19	94950	523928	6752187

Highway Section	***Waterway***	***Site Identifier***	***Identifier from Pre-Const'n***	***Approx. Chainage***	***Easting***	***Northing***
Section 6 - Iluka Road to Devils Pulpit	Mororo Creek (North)	SW6-01	SW20	96700	523613	6753865
		SW6-02			523517	6753823
	Tabbimobile Creek	SW6-03	SW21	101650	521092	6758080
		SW6-04			521269	6758168
	Tabbimobile Overflow	SW6-05	SW25	102850	520522	6759162
		SW6-06			520697	6759323
Section 7 - Devils Pulpit to Trustums Hill	Unnamed	SW7-01	SW01	114000	525617	6769018
		SW7-02			525747	6768772
	Tabbimoble Floodway	SW7-03	SW02	115300	526338	6770283
		SW7-04			526395	6770003
	Oaky Creek	SW7-05	SW03	122400	530058	6775786
		SW7-06			530116	6775685
	South of the intersection with the existing Pacific Highway and Norton's Road	SW7-07	SW04	124400	531223	6777369
		SW7-08			531315	6777327
Section 8 - Trustums Hill to Broadwater National Park	Tuckombil Canal (becomes Evans River)	SW8-01	SW05	130100	533366	6782359
		SW8-02			533465	6782226
	Unnamed watercourse at CH 134 700 m	SW8-03	SW06	134800	537269	6784426
		SW8-04			537309	6784720
	Unnamed tributary of MacDonald's Creek CH 136 450 m	SW8-05	SW07	135350	537954	6784929
		SW8-06			537912	6785047
	MacDonald's Creek	SW8-07	SW08	136600	538158	6786141
		SW8-08			538057	6786078
Section 9 - Broadwater National Park to Richmond River	Montis Gully	SW9-01	SW09	140950	540725	6788937
		SW9-02			540849	6789051
	Everson's Creek	SW9-03	SW10	143400	543235	6790040
		SW9-04			543415	6790313

Highway Section	*Waterway*	*Site Identifier*	*Identifier from Pre-Const'n*	*Approx. Chainage*	*Easting*	*Northing*
Section 10 - Richmond River to Coolgardie Road	Richmond River	SW10-01	SW11	145900	542708	6792345
		SW10-02			542801	6792343
	Pond / wetland	GDE07	GDE07	148800	542202	6795080
	Unnamed tributary Bingal Creek CH 149 250 m	SW10-03	SW12	149300	541901	6795398
		SW10-04			542052	6795483
	Saltwater Creek	SW10-05	SW13	157200	546054	6800315
		SW10-06			546399	6800244
	Randal's Creek	SW10-07	SW14	157800	546289	6800832
		SW10-08			546285	6800456
Section 11 - Coolgardie Road to Ballina Bypass	Duck Creek	SW11-01	SW15	164400	548432	6806741
		SW11-02			548847	6806576

2.2 Groundwater Monitoring

There are a total of 132 groundwater bores to be monitored for groundwater levels. The bores are associated with significant cuts and fill embankments. Of the 132 bores, 64 will be monitored for water quality. The bores are listed in **Table 2.2** and mapped in **Appendix A**.

The objectives of the groundwater monitoring are:

- Assess the potential impact of the highway upgrade cut structures on groundwater levels and groundwater quality.
- Assess the potential impact of the highway upgrade on groundwater in order to protect licenced bores, waterways and watercourses, and groundwater dependent ecosystems.

Table 2.2 List of Bores for Groundwater Monitoring

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Monitoring for	
						Level	Quality[1]
Section 3 - Glenugie to Tyndale	GWB3-01	PZ05	38750	503800	6707549	Y	-
	GWB3-02	PZ06	38650	503931	6707495	Y	-
	GWB3-03	PZ07	39350	504168	6708111	Y	-
	GWB3-04	PZ08	39300	504194	6707984	Y	-
	GWB3-05	PZ09	39800	504540	6708366	Y	Y
	GWB3-06	PZ10	39800	504575	6708258	Y	Y
	GWB3-07	PZ13	42950	507650	6708670	Y	Y
	GWB3-08	PZ14	42950	507664	6708562	Y	Y
	GWB3-09	PZ15	43750	508420	6708859	Y	-

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Monitoring for	
						Level	Quality[1]
	GWB3-10	PZ16	43750	508441	6708759	Y	-
	GWB3-11	PZ17	45900	510559	6709323	Y	-
	GWB3-12	PZ18	45900	510498	6709447	Y	-
	GWB3-13	PZ19	46200	510796	6709494	Y	Y
	GWB3-14	PZ20	46200	510692	6709581	Y	Y
	GWB3-15	PZ21	46500	511018	6709716	Y	-
	GWB3-16	PZ22	46500	510909	6709795	Y	-
	GWB3-17	PZ23	46800	511188	6710017	Y	Y
	GWB3-18	PZ24	46800	511100	6710064	Y	Y
	GWB3-19	PZ25	47750	511604	6710840	Y	-
	GWB3-20	PZ26	47750	511506	6710867	Y	-
	GWB3-21	PZ27	48350	511892	6711361	Y	Y
	GWB3-22	PZ28	48350	511777	6711419	Y	Y
	GWB3-23a[2]	PZ29	51950	512155	6714825	Replaced by 23b	
	GWB3-24a[2]	PZ30	51950	512035	6714815	Replaced by 24b	
	GWB3-23b[2]	-	52100	512155	6714825	Y	-
	GWB3-24b[2]	-	52100	511965	6714981	Y	-
	GWB3-25[3]	PZ31[3]	52400	512239	6715255	-	-
	GWB3-26[3]	PZ32[3]	52400	512106	6715277	-	-
	GWB3-27[3]	PZ34[3]	52500	512129	6715393	-	-
	GWB3-28	PZ35	53150	512373	6715987	Y	Y
	GWB3-29	PZ36	53150	512253	6716011	Y	Y
	GWB3-30	PZ37	54150	512623	6716934	Y	Y
	GWB3-31	PZ38	54150	512432	6716970	Y	Y
	GWB3-32	PZ39	55400	512966	6718146	Y	Y
	GWB3-33	PZ40	55400	512830	6718165	Y	Y
	GWB3-34	PZ41	57100	513237	6719796	Y	Y
	GWB3-35	PZ43	58000	513567	6720628	Y	Y
	GWB3-36	PZ44	58000	513485	6720658	Y	Y
	GWB3-37	BH1139	59650	513924	6722241	Y	Y
	GWB3-38	PZ45	59600	513768	6722169	Y	Y
	GWB3-39	PZ46	63300	513228	6725646	Y	Y
	GWB3-40	PZ47	63300	513037	6725647	Y	Y

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Monitoring for	
						Level	Quality[1]
	GWB3-41	PZ48	64850	513362	6727143	Y	Y
	GWB3-42a[2]	PZ49	64850	513450	6727131	Replaced by 42b	
	GWB3-42b[2]	-	64850	513445	6727070	Y	Y
	GWB3-43	BH1159	66600	514247	6728732	Y	Y
	GWB3-44	BH1170	66850	514237	6728999	Y	-
	GWB3-45	PZ50	66850	514199	6729026	Y	Y
	GWB3-46	PZ51	67700	514778	6729714	Y	Y
	GWB3-47	BH1187	67650	514551	6729679	Y	Y
	GWB3-48	BH1197	68250	514866	6730253	Y	-
	GWB3-49	PZ52	68250	514688	6730300	Y	-
	GWB3-50	BH1200	68500	514995	6730479	Y	Y
	GWB3-51	PZ53	68550	514804	6730578	Y	Y
Section 4 - Tyndale to Maclean	GWB4-01	BH1206	69250	515435	6730961	Y	Y
	GWB4-02	PZ54	69200	515291	6731062	Y	Y
	GWB4-03	PZ55	69950	516029	6731287	Y	-
	GWB4-04	PZ56	69900	515966	6731183	Y	-
	GWB4-05	PZ57	72350	518250	6732024	Y	Y
	GWB4-06	PZ58	72350	518150	6732073	Y	Y
	GWB4-07	PZ59	74650	519139	6734040	Y	-
	GWB4-08	PZ60	74650	519035	6734056	Y	-
	GWB4-09	BH1251	76100	519649	6735373	Y	Y
	GWB4-10	BH1259	76350	519520	6735678	Y	Y
	GWB4-11	BH1261	76650	519699	6735969	Y	Y
	GWB4-12	PZ61	76650	519552	6735944	Y	Y
	GWB4-13	PZ62	77400	519561	6736701	Y	-
	GWB4-14	PZ63	77400	519682	6736678	Y	-
	GWB4-15	PZ64	77650	519613	6736940	Y	-
	GWB4-16	PZ65	77600	519714	6736899	Y	-
	GWB4-17	PZ66	78200	519674	6737500	Y	Y
	GWB4-18	BH1359	78200	519820	6737505	Y	Y
	GWB4-19	PZ67	80050	520114	6739294	Y	-
	GWB4-20	PZ68	80150	520015	6739409	Y	-
	GWB4-21	PZ69	80450	519892	6739746	Y	Y
	GWB4-22[3]	PZ70[3]	80600	520197	6739816	-	-

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Monitoring for	
						Level	Quality[1]
Section 5 - Maclean to Iluka Road	GWB5-01	PZ71	85800	523248	6743591	Y	Y
	GWB5-02	PZ72	85800	523464	6743593	Y	Y
	GWB5-03	GBH110	89300	523608	6747043	Y	Y
	GWB5-04	PZ73	89300	523479	6747035	Y	Y
	GWB5-05	PZ74	90600	523067	6748311	Y	-
	GWB5-06	PZ75	90650	523273	6748349	Y	-
Section 6 - Iluka Road to Devils Pulpit	Section 6 does not contain significant cuttings or areas of extensive fill for construction of the Pacific Highway Upgrade.						
Section 7 – Devils Pulpit to Trustums Hill	GWB7-01	BH1221	114600	525990	6769467	Y	-
	GWB7-02[3]	BH1222	118450	527308	6773019	-	-
	GWB7-03[3]	BH1223[3]	120650	528793	6774669	-	-
	GWB7-04	BH1224	120650	528732	6774720	Y	-
	GWB7-05	BH1225	123000	530769	6776068	Y	-
	GWB7-06	BH1226	124800	531417	6777634	Y	-
	GWB7-07	BH1227	124800	531389	6777691	Y	-
Section 8 – Trustums Hill to Broadwater National Park	GWB8-01	BH1228	128450	533119	6780685	Y	-
	GWB8-02	BH1229	128450	532759	6780698	Y	-
	GWB8-03[3]	BH1230[3]	129200	533163	6781429	-	-
	GWB8-04	BH1231	129200	533041	6781443	Y	Y
	GWB8-05	BH1232	129700	533232	6781942	Y	-
	GWB8-06	BH1233	129700	533140	6781982	Y	-
	GWB8-07	BH1234	130050	533405	6782246	Y	Y
	GWB8-08	BH1235	130050	533340	6782299	Y	Y
	GWB8-09	BH1236	130600	533823	6782582	Y	-
	GWB8-10	BH1237	130600	533790	6782648	Y	-
	GWB8-11	BH1238	131400	534559	6782844	Y	-
	GWB8-12	BH1239	131400	534541	6782734	Y	-
	GWB8-13	BH1240	132050	535059	6783189	Y	-
	GWB8-14	BH1241	132050	535176	6783122	Y	Y
	GWB8-15	BH1242	132150	535405	6783078	Y	Y
	GWB8-16	BH1243	132200	535221	6783271	Y	Y
	GWB8-17	BH1244	132250	535086	6783430	Y	Y

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Monitoring for	
						Level	Quality[1]
	GWB8-18	BH1245	132750	535592	6783655	Y	-
	GWB8-19	BH1246	132800	535710	6783622	Y	-
	GWB8-20	BH1247	134050	536728	6784264	Y	-
	GWB8-21	BH1248	134150	536892	6784238	Y	-
	GWB8-22	BH1249	134850	537331	6784734	Y	Y
	GWB8-23	BH1250	134800	537457	6784496	Y	Y
	GWB8-24	BH1251	136550	538149	6786022	Y	-
	GWB8-25	BH1252	136550	538072	6786029	Y	-
	GWB8-26	BH1253	137050	538194	6786529	Y	Y
Section 9 - Broadwater National Park to Richmond River	GWB9-01	BH1254	137650	538508	6787013	Y	Y
	GWB9-02	BH1255	137700	538424	6787105	Y	Y
	GWB9-03	BH1256	140250	540252	6788872	Y	Y
	GWB9-04A[4]	BH1257[4]	140250	540323	6788776	Y	Y
	GWB9-04B	-	140550	540520	6788997	Y	Y
	GWB9-05	BH1258	140950	540900	6788960	Y	-
	GWB9-06	BH1259	140950	540891	6789043	Y	-
	GWB9-07	BH1260	141400	541379	6789029	Y	Y
	GWB9-08	BH1261	141400	541359	6789098	Y	Y
	GWB9-09	BH1262	141900	541900	6789172	Y	-
	GWB9-10	BH1263	141950	541871	6789281	Y	-
	GWB9-11	BH1264	142950	542767	6789776	Y	-
	GWB9-12	BH1265	143100	542984	6789752	Y	-
	GWB9-13	BH1266	143900	543281	6790470	Y	-
	GWB9-14	BH1267	144000	543431	6790523	Y	-
	GWB9-15[4]	BH1268[4]	145000	543247	6791425	-	-
	GWB9-16[4]	BH1269[4]	145000	543330	6791460	-	-
Section 10 – Richmond River to Coolgardie Road	GWB10-01	BH1270	147450	542590	6793770	Y	Y
	GWB10-02	BH1271	147750	542371	6794014	Y	Y
	GWB10-03	BH1272	148300	542327	6794540	Y	-
	GWB10-04	BH1273	148350	542220	6794559	Y	Y
	GWB10-05	BH1274	148450	542250	6794686	Y	-
	GWB10-06	BH1275	148800	542017	6795003	Y	-
	GWB10-07	BH1276	148950	542057	6795155	Y	-
	GWB10-08	BH1277	149050	541863	6795231	Y	-

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Monitoring for	
						Level	Quality[1]
	GWB10-09	BH1278	152450	542562	6798396	Y	Y
	GWB10-10[3]	BH1279[3]	157200	546077	6800224	-	-
	GWB10-11	BH1280	157350	545995	6800401	Y	Y
	GWB10-12[3]	BH1281[3]	157400	546166	6800383	-	-
	GWB10-13[3]	BH1282[3]	157600	546237	6800555	-	-
Section 11 – Coolgardie Road to Ballina Bypass	GWB11-01	BH1283	159600	546663	6802507	Y	-
	GWB11-02	BH1284	159600	546744	6802497	Y	-
	GWB11-03	BH1285	163000	547664	6805746	Y	Y
	GWB11-04	BH1286	163050	547735	6805763	Y	Y

Note: 1. Pre-construction water quality monitoring consisted of EC, pH and temperature for the nominated bores in Sections 3-6 and only pH readings for the nominated bores in Sections 7-11.
2. GWB3-23a, GWB3-24a and GWB3-42a (PZ29, PZ30 and PZ49) are outside the realignment and will be replaced by new bores: GWB3-23b, GWB3-24b and GWB3-42b
3. These bores will not be monitored in the construction / operational phases.
4. GWB9-04, GWB9-15 and GWB9-16 (BH1257, 1268 and 1269) have not been constructed.

3

Summary of Pre-Construction Monitoring

Pre-construction monitoring of surface waters and groundwater was undertaken between January 2013 and January 2014 by:

- Coffey Geotechnics Pty Ltd for Sections 3 to 6 (referred to as Glenugie to Devils Pulpit - G2DP) and
- Golder Associates Pty Ltd for Sections 7 to 11 (referred to as Devils Pulpit to Ballina - DP2B).

A total of 43 surface water sampling sites were monitored. The construction monitoring will continue monitoring at each of these sites with the exception of two ponds that will be filled by the highway works.

A total of 142 groundwater bores were monitored. Each bore was monitored for groundwater levels, and 113 of the bores were monitored for basic water quality parameters. Three bores adjoining the Rous Water Woodburn borefield in Section 8 were also monitored for a large range of water quality parameters.

Details of the pre-construction monitoring results for each highway section (3 to 11) are contained in **Appendices B to J**.

3.1 Surface Water Monitoring

The surface water locations monitored in the pre-construction phase are listed in **Table 3.1**.

Appendices B to J provide the following surface water monitoring data for highway sections 3 to 11 respectively:

- List of the monitoring locations and associated sensitive receiving environments
- An overview of the water quality monitoring results in regard to physical properties, chemical properties, hydrocarbons, nutrients, and heavy metals
- A summary of the visual observations and sampling results for each monitoring site
- A summary of the water quality statistics (median, minimum, maximum etc) for each monitoring site.

3.1.1 Number of Monitoring Events

Surface water quality monitoring for Sections 3 to 6 involved a total of 15 monitoring events - 11 dry weather events and 4 wet weather events. Surface water quality monitoring for Sections 7 to 11 involved a total of 13 monitoring events in 2013 (approximately monthly).

3.1.2 Number of Monitoring Locations

Sections 3 to 6

A total of 25 sites were monitored for Sections 3 to 6 which included some groundwater dependent ecosystems (GDE's) as described for each section in the details provided in **Appendices B to E**.

Sections 7 to 11

A total of 25 sites were monitored for Sections 7 to 11 which included:

- nine SW sites (SW04, SW05, SW06, SW07, SW09, SW10, SW11, SW12, SW14)
- three GDE sites (GDE04, GDE05, GDE07)
- six combined SW / GDE sites (SW01 / GDE01, SW02 / GDE02, SW03 / GDE03, SW08 / GDE06, SW13 / GDE08, SW15 / GDE09)

Table 3.1 Surface Water / GDE Quality Monitoring Locations

Highway Section	Waterway	Identifier from Pre- Construction Phase	Approx. Chainage
Section 3	Picanny Creek	SW01	35700
	Pheasant Creek	SW02	36300
	Unnamed tributary Glenugie Creek	SW03	36900
	Coldstream River	SW04	42400
	Coldstream River	SW05	43350
	Pillar Valley Creek	SW06	46400
	Black Snake Creek	SW07	46600
	Unnamed Creek tributary of Ellis Swamp	SW22	50400
	Chaffin Creek	SW08	52450
	Unnamed tributary of Chaffin Creek	SW09	54700
	Chaffin Creek	SW10	57100
	Unnamed bodies of water	SW11	58700
	South Arm Clarence River	SW12	67950
Section 4	Shark Swamp Overflow	SW23	73400
	Shark Creek	SW13	74950
	Edwards Creek	SW14	80200
Section 5	Yaegl Wetland	SW24	84400
	Unnamed tributary of James Creek	SW15	85100
	Clarence River	SW16	86300
	Serpentine Channel	SW17	89350
	North Arm (Clarence River)	SW18	94200
	Mororo Creek (South)	SW19	94950
Section 6	Mororo Creek (North)	SW20	96700
	Tabbimobile Creek	SW21	101650
	Tabbimobile Overflow	SW25	102850
Section 7	Unnamed	SW01 / GDE01	114000
	Tabbimoble Floodway	SW02 / GDE02	115300
	Oaky Creek	SW03 / GDE03	122400
	South of the intersection with the existing Pacific Highway and Norton's Road	SW04	124400

Highway Section	Waterway	Identifier from Pre- Construction Phase	Approx. Chainage
Section 8	Tuckombil Canal (becomes Evans River)	SW05	130100
	Small pond / wetland. Generally dry. Located in footprint of highway upgrade	GDE04	130300
	Large pond / wetland. Located in footprint of highway upgrade	GDE05	133350
	Unnamed watercourse	SW06	134700
	Unnamed tributary of MacDonald's Creek	SW07	136450
	MacDonald's Creek	SW08 / GDE06	136600
Section 9	Montis Gully	SW09	140950
	Everson's Creek	SW10	143400
Section 10	Richmond River	SW11	145900
	Large pond / wetland.	GDE07	148830
	Unnamed tributary Bingal Creek	SW12	149250
	Saltwater Creek	SW13 / GDE08	157200
	Randal's Creek	SW14	157800
Section 11	Duck Creek	SW15 / GDE09	164400

3.1.3 Surface Water Monitoring Parameters

Sections 3 to 6

The following parameters were monitored were measured in the field during each monitoring event:

- pH
- Dissolved oxygen (DO)
- Electrical conductivity (EC)
- Temperature
- Turbidity.

Samples were also tested for the following laboratory analysis parameters:

- Total Suspended Solids
- Oil and Grease
- Total Phosphorous and Total Nitrogen
- Cations (Ammonia, Calcium, Magnesium)
- Metals (Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver and Zinc).

Sections 7 to 11

The following parameters were monitored were measured in the field:

- pH
- Dissolved oxygen (DO)
- Electrical conductivity (EC)
- Redox potential

- Temperature
- Turbidity.

Samples were also tested for the following laboratory analysis parameters (please note that not all sites were tested for all the following parameters):
- Total Suspended Solids
- Oil and Grease
- Total Petroleum Hydrocarbons
- Total Phosphorous and Total Nitrogen
- Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen
- Cations (Calcium, Magnesium)
- Metals (Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver and Zinc).

The Groundwater Dependent Ecosystem monitoring locations were also tested for major cations and anions in addition to the above parameters.

3.2 Groundwater Monitoring

The groundwater locations monitored in the pre-construction phase are listed in **Table 2.2** under the column heading "Identifier from Pre-Construction" with the exception of BH1257, 1268 and 1269 in Section 9 which had not been constructed during the pre-construction phase.

3.2.1 Groundwater Levels

Groundwater level monitoring was undertaken for all 142 groundwater bores. The automatic data loggers recorded at one hour intervals for Sections 3 to 6 and 15 minute intervals for Sections 7 to 11. Plots of the groundwater level at each bore are shown in **Appendices B to J**.

3.2.2 Groundwater Quality

Statistics for the groundwater quality for each bore are shown in **Appendices B to J**.

Number of Monitoring Events

In both Sections 3 to 6 and Sections 7 to 11 groundwater quality was monitored four times (quarterly) in 2013.

Number of Monitoring Locations

- 77 bores in Sections 3 to 6 (essentially all the bores in Sections 3 to 6 excluding PZ06 and PZ07 which were dry).
- 36 bores in Sections 7 to 11 as nominated in **Table 2.2** which are located in areas of proposed fill embankments.

Monitoring Parameters

In Sections 3 to 6, the bores were monitored for in-situ parameters of pH, EC and temperature.

In Sections 7 to 11, the bores were monitored for pH only, with the exception of three bores in Section 8 (BH1242, BH1243 and BH1244) which were monitored for pH, EC, TDS, hydrocarbons, nutrients, major cations and anions, and heavy metals.

4

Sampling Regime and Parameters

4.1 Monitoring Duration

The minimum monitoring period for the construction and operational phases of the project are:

- Construction phase: for the duration of the construction period. Commencement of construction is defined by approval by NSW Department of Planning and Environment of the Construction Environmental Management Plan for the main construction activities on site; and
- Operational phase: a minimum of three years following completion of Construction as defined in the project approval or until the affected waterways and/or groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition. The monitoring shall also confirm the establishment of operational water control measures (such as sedimentation basins and vegetation swales) (refer to infrastructure approval Condition D12 in **Section 1.2** of this report).

4.2 Surface Water

4.2.1 Construction Phase

Sampling over the construction monitoring period will comprise:

- one wet event sampling round per month:
  - Type A parameters (refer to **Table 4.1**) every month; plus
  - Type B parameters (refer to **Table 4.1**) every second month
- one dry event sampling round per month:
  - Type A parameters every month; plus
  - Type B parameters every second month.

Table 4.1 Surface Water Sampling Parameters – Construction Phase

Parameter		*Type A Parameters*	*Type B Parameters*
pH	(measured in the field)	X	
Temperature	(measured in the field)	X	
Electrical Conductivity (EC)	(measured in the field)	X	
Dissolved Oxygen (DO)	(measured in the field)	X	
Turbidity	(measured in the field)	X	
Total Suspended Solids (TSS)			X
Total Oils and Grease (include as Type A parameter if oil/grease is visible)		*	X
Total Phosphorous, Total Nitrogen			X
Total Petroleum Hydrocarbons (TPH) (include as Type A parameter if oil/grease is visible)		*	X

* Note: TPH to be analysed as a Type A parameter if oil/grease is visible

Wet events are defined as 15mm or more of rain within 24 hours. Wet event sampling is to be undertaken within 48 hours of the rain event. Refer to **Section 4.4** regarding rainfall information.

Following the initial 12 months, the sampling regime shall be reviewed by the Environmental Review Group in consideration of the monitoring results. The review shall consider:

- if the frequency of some of the sampling can be reduced or needs increasing; or
- if some analytes / parameters / locations can be omitted from the sampling.

The above review may also be undertaken following the initial 18 months to assess if any changes to the sampling regime are warranted.

4.2.2 Operational Phase

In general terms monthly monitoring is proposed for the first year of operation after which time it is assumed that revegetation will have generally established and stabilised. Following the first year the frequency will be reduced to once every second month for the second year of operation and then once every six months for the third year of operation.

4.2.2.1 Operational Phase – First Year of Operation

Sampling over the first year of the operational phase will comprise:

- one **wet event** sampling round per quarter:
  - Type A parameters every quarter (refer to **Table 4.2**); plus
  - Type B parameters every second quarter (refer to **Table 4.2**).
- one **dry event** sampling round every six months (two rounds in the first year of operation):
  - Type A and Type B parameters.

Table 4.2 Surface Water Sampling Parameters – Operational Phase

Parameter		*Type A Parameters*	*Type B Parameters*
pH	(measured in the field)	X	
Temperature	(measured in the field)	X	
Electrical Conductivity (EC)	(measured in the field)	X	
Dissolved Oxygen (DO)	(measured in the field)	X	
Turbidity	(measured in the field)	X	
Total Suspended Solids (TSS)			X
Total Oils and Grease (include as Type A parameter if oil/grease is visible)		*	X
Total Phosphorous, Total Nitrogen			X
Total Petroleum Hydrocarbons (TPH) (include as Type A parameter if oil/grease is visible)		*	X
Heavy Metals (Total): Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Zinc			X

* Note: TPH to be analysed as a Type A parameter if oil/grease is visible

4.2.2.2 Operational Phase – Second and Third Year of Operation

Sampling over the second year of the operational phase will comprise:

- one **wet event** sampling round every six months assessing both Type A and Type B parameters
- one **dry event** sampling round every six months assessing both Type A and Type B parameters.

4.3 Groundwater

4.3.1 Groundwater Level Monitoring Regime

Groundwater level monitoring will be undertaken at each of the 132 groundwater bores nominated in **Table2.2** using automatic water level recorders.

4.3.1.1 Construction Phase

The automatic water level recorders will be set to take readings at a maximum of one hour intervals with data downloaded quarterly.

Quarterly downloads will include physical measurement of total depth of the bore and depth to standing water level at each monitoring bore for correlation with the automatic recordings. The total depth of the bore and depth to standing water level is to be measured before any sampling.

Following the initial 12 months, the groundwater level recording / download frequency shall be reviewed by the Environmental Review Group to assess if any changes are warranted. This review may also be undertaken following the initial 18 months to assess if any changes are warranted.

4.3.1.2 Operational Phase – First Year of Operation

The automatic water level recorders will be set to take readings at a maximum of one hour intervals with data downloaded quarterly.

Quarterly downloads will include physical measurement of total depth of the bore and depth to standing water level at each monitoring bore for correlation with the automatic recordings. The total depth of the bore and depth to standing water level is to be measured before any sampling.

4.3.1.3 Operational Phase – Second and Third Year of Operation

The automatic water level recorders may be set to take readings at a max of three hour intervals if considered suitable based on review of data from first year of operation. The maximum period between downloading and calibration will be six months.

Downloads will include physical measurement of total depth of the bore and depth to standing water level at each monitoring bore for correlation with the automatic recordings. The total depth of the bore and depth to standing water level is to be measured before any sampling.

4.3.2 Groundwater Quality Sampling Regime

4.3.2.1 Construction Phase

Sampling over the construction monitoring period will comprise:

- quarterly sampling of Type A parameters (field analysis parameters - refer to **Table 4.3**) plus
- six-monthly sampling of Type B parameters (laboratory analysis parameters - refer to **Table 4.3**)

Sampling will be conducted on the 64 groundwater bores nominated in **Table 2.2** for quality monitoring. The number of bores and the parameters to be monitored is subject to review following the initial 12 months of monitoring as described below.

Following the initial 12 months, the sampling regime shall be reviewed by the Environmental Review Group in consideration of the monitoring results. The review shall consider:

- if the frequency of some of the sampling can be reduced or needs increasing; or
- if some analytes / parameters / locations can be omitted from the sampling.

The above review may also be undertaken following the initial 18 months.

4.3.2.2 Operational Phase – First Year of Operation

Sampling over the first year of the operational phase will comprise six-monthly monitoring of both Type A and B parameters. The number / location of the bores and the sampling parameters shall be based on the construction sampling regime resulting from the review by the Environmental Review Group as described in **Section 4.3.2.1**.

4.3.2.3 Operational Phase – Second and Third Year of Operation

Sampling over the second and third year of the operational phase will comprise annual monitoring of both Type A and B parameters. The number / location of the bores and the sampling parameters shall be based on the construction sampling regime resulting from the review by the Environmental Review Group as described in **Section 4.3.2.1**.

Table 4.3 Groundwater Quality Sampling Parameters

Parameter/Analytical Group	*Analytes*	*Type A Parameters (Field analysis)*	*Type B Parameters (Laboratory analysis)*
Physical and chemical properties	pH	X	
	Temperature	X	
	Electrical Conductivity (EC)	X	
Hydrocarbons	Total Petroleum Hydrocarbons (TPH)		X
Nutrients	Total Phosphorous, Total Nitrogen		X
Major Cations	sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+})		X
Major Anions	chloride (Cl^-), sulfate (SO_4^{2-}), bicarbonate (HCO^{3-})		X
Heavy Metals (Dissolved)	Aluminium, Cadmium, Copper, Lead, Zinc		X

4.4 Rainfall Data

For the construction phase rainfall data shall be collected from a range of weather stations including existing BoM stations and site construction weather stations where available. . As noted previously, 'wet events' are defined as 15mm or more of rain within 24 hours.

It is noted that the pre-construction monitoring utilised daily rainfall figures from the following Bureau of Meteorology (BoM) sites:

- Grafton Airport – Station No. 058130: Lat. 29.68 ºS, Long. 152.93 ºE, Elevation 9m.
- Yamba Pilot Station – Station No. 058012: Lat. 29.43 ºS, Long. 153.36 ºE, Elevation 27m.
- Evans Head Station – Station No. 058164: lat. 29.133 ºS, Long. 153.45 ºE, Elevation 31m.

Sampling Methodology

5.1 Pre-Monitoring Tasks

5.1.1 Rainfall Monitoring

Daily records of rainfall will be obtained from the construction site weather stations (refer to **Section 4.4**). This information will be checked/reviewed daily to determine if local rainfall events may trigger a wet weather surface water sampling event as required in **Section 4.2**.

5.1.2 Calibration

The field water quality probe used for surface and groundwater monitoring is to be calibrated in accordance with the manufacturer's recommendations. Any pre-sampling equipment and calibration checks recommended by the manufacturer are to be completed prior to each sampling round. Where sampling extends beyond one day, the probe is to be rechecked for each subsequent day of use. Calibration record sheets are to be completed and retained on the project file.

5.1.3 Preparation of Sample Containers

Sample containers suitable for the required laboratory analysis will be sourced from the laboratory prior to the commencement of monitoring rounds. Sample containers will be labelled prior to field sampling to reduce the potential for labelling errors made in the field.

5.1.4 Sampling equipment

Testing equipment required for surface water monitoring consists of the following:

- water quality probe
- sampling pole
- sample bottles supplied by the laboratory
- chilled insulated container/esky and ice
- additional sample bottles for ex-situ field measurements where required (refer to **Section 5.2.2**)
- camera
- GPS
- field sheets.

Testing equipment required for the groundwater monitoring component will include:

- water quality probe
- electronic dip (water level) meter
- tape measure for measuring depth of bores
- laptop/notebook with software loaded and operational, water level logger licence key and USB cable
- sample bottles supplied by the laboratory
- chilled insulated container/esky and ice
- additional sample bottles for ex-situ field measurements
- camera
- GPS
- field sheets.

5.2 Surface Water Sampling

5.2.1 Field Observations

Observations will be recorded in field sheets at each sampling location upon arrival at the site. This will include:

- date and time of sampling
- weather conditions including air temperature and percentage of cloud cover
- general observations on the condition of the water body such as water colour, stream flow, evidence of recent flooding, any odour, any visible signs of oil/grease on the water surface, gross pollutants, other pollution or other disturbances including relevant adjacent land use activity
- photographic records.

5.2.2 Collection of In-Situ Water Quality Data

The following parameters are to be measured in the field for each monitoring round using a calibrated water quality probe:

- pH
- Temperature
- Electrical Conductivity (EC)
- Dissolved oxygen (DO)
- Turbidity (NTU).

The field measurements are to be made prior to the collection of samples for laboratory analysis. The measurements are to be noted on the field sheets for each surface water monitoring site.

The water quality probe is to be placed approximately 0.5 metres below the water surface or mid-depth in the water column for shallow sites. The water quality readings will be allowed to stabilise before reading/recording in accordance with the manufacturer's instructions.

Where safety concerns do not allow for sampling in-stream (or depth is too shallow for effective probe deployment), a sample may be collected using an appropriate sampling device and measurements undertaken on the stream bank. Where this methodology is employed it will be recorded on the field sheets. To avoid contamination of samples, field measurements are to be made on samples of water separate to samples collected for laboratory analysis.

All equipment will be decontaminated between sampling sites.

5.2.3 Collection of Water Samples for Laboratory Analysis

Water samples will be collected by immersion of a sample bottle on a pole to 0.5 metres below the water surface or mid-depth in the water column for shallow sites. The sample bottle will be rinsed three times with sample water prior to obtaining sample. Rinse water will be emptied downstream of the sampling location to avoid contamination of the sample.

All samples will be stored in a chilled esky and transported to the laboratory as soon as practical.

5.2.3.1 Replicate Samples

One blind replicate water sample will be collected for every 10 samples every monitoring round for laboratory analysis. Blind replicate samples will be submitted to the laboratory as individual samples without any indication to the laboratory that they are replicates.

5.3 Groundwater Sampling

5.3.1 Field Observations

Observations will be recorded in field sheets at each sampling location upon arrival at the site. This will include:

- date and time of sampling
- weather conditions including air temperature and percentage of cloud cover
- general observations on the condition of the groundwater bore, any visible signs of contamination or other disturbances
- photographic records.

5.3.2 Collection of Groundwater Standing Water Levels

Prior to extracting the automatic water level recorders or any purging/sampling, each monitoring well will be gauged by measuring:

- depth to standing water level with an electronic dip (water level) meter
- total depth of the bore. The total depth of the bore is required as the base of the monitoring bores can silt up, and this can occur to the top of the slotted/screened interval. Comparing the measured total depth reading with the depth documented at the time of construction can be useful to determine the status of the bore (Sundaram et. al., 2009:24).

The above measurements will be made from a standard reference point on each of the well casings which will be noted on the field sheets. The readings will be recorded as depth from the Top of Casing (TOC).

The automatic water level recorder will then be extracted at each monitoring well for transfer of data to a laptop/notebook using a compatible shuttle. At the completion of the monitoring event the shuttle will be downloaded and data collected from each well will be stored in a Microsoft Excel spread sheet. The field level data for each monitoring well will be corrected for barometric pressure and converted to a standing water level (SWL). This converted data will then be used to plot the SWL over time for each monitoring well.

5.3.3 Collection of Field Groundwater Quality Data

The following parameters are to be measured in the field for each monitoring round using a calibrated water quality probe:

- pH
- temperature
- electrical conductivity (EC)
- dissolved oxygen (DO)
- turbidity (NTU).

The field measurements are to be made following purging of the wells and prior to the collection of samples for laboratory analysis. The measurements are to be noted on the field sheets for each groundwater monitoring site.

All equipment will be decontaminated between sampling sites.

5.3.4 Collection of Groundwater Samples for Laboratory Analysis

Groundwater samples can be obtained by either a passive sampling approach or purging.

5.3.4.1 Passive Sampling

A passive sampling approach will utilise a “Hydrasleeve” or similar. The Hydrasleeve is a tool used for passive groundwater sampling that has been specifically designed to capture a “core” sample of water from a user-defined interval/portion of the well.

A one way reed valve allows the Hydrasleeve to be lowered into the well (with the use of a weight and string cut to the desired length) as a thin empty plastic sleeve, thereby preventing the mixing of fluid from higher up the water column. The groundwater sample collection process will involve the placement of Hydrasleeves at a depth of three meters below the top of the screen (or in the case of low yield wells, to the bottom of the well). Once lowered to the desired depth, the Hydrasleeve will be left for a minimum period of one week before being withdrawn and the required groundwater sample retrieved for laboratory analysis. Note that this lag time of one week is a precautionary measure to allow the water in the well to re-equilibrate, should any mixing have occurred.

Given that the Hydrasleeve is a single use item, each Hydrasleeve will be disposed of appropriately upon withdrawal from the well. After the sample has been retrieved from the Hydrasleeve and transferred to the corresponding laboratory supplied bottles for analysis, a new Hydrasleeve will be set up and deployed for retrieval during the next round of monitoring. By taking this passive groundwater sampling approach, the bore does not require purging prior to every sampling event.

5.3.4.2 Purging

Prior to the collection of water samples for analysis each well will be purged. The wells will be purged using either an electric purge pump or a decontaminated stainless steel bailer until the following criteria is met:

- a minimum of three well volumes have been removed from the well; or
- the well has been purged dry.

The purging method will be recorded on the field sheet.

Collection of groundwater samples for laboratory analysis will be undertaken following purging and field measurements. All equipment will be decontaminated between sampling sites.

5.3.5 Replicate Samples

One blind replicate water sample will be collected for every 10 samples every monitoring round for laboratory analysis. Blind replicate samples will be submitted to the laboratory as individual samples without any indication to the laboratory that they are replicates.

6

Quality Management

6.1 Sample Identification and Records

Sample containers will be labelled clearly and include the following information:

- job reference number
- sample location name (e.g. SW01)
- time and date sampled.

A field sheet will be completed for each surface water and groundwater sampling location. The field sheet will include the following details:

- sample location name
- date and time of sampling
- sample equipment used
- name of field personnel
- weather conditions
- field water quality parameter measurements
- water level details including depth to water and total depth within groundwater monitoring bores
- visual and odour observations – refer to **Section 5.2.1** and **5.3.1**
- QA/QC sample collection details – refer to **Section 6.7**

6.2 Sample Collection

To ensure the integrity of all samples taken, the sampling protocol includes the following basic precautions for avoiding contamination during sample collection:

- containers supplied by the analytical laboratory will be utilised
- all field equipment will be pre-cleaned
- sample bottles suitable for each parameter will be used
- containers will be uncapped or removed from their transport bags for minimum amounts of time.

6.3 Sample Preservation and Transport

Water samples are to be collected in laboratory supplied containers and will be kept on ice in a chilled insulated container. Samples are to be couriered to the laboratory under chain of custody protocol within one day of sampling.

6.4 Chain of Custody

Chain of custody documentation to be recorded as part of the sampling program is detailed in **Table 6.1**.

Table 6.1 Chain of Custody Documentation

Process Step	*Quality Assurance Procedure*
Field sampling	Field register of sample number, site, type/technique, time, date, technician, field data sheet
Sample storage and transport	Field register of transport container number and sample numbers, time, date
Laboratory receipt of samples	Laboratory register of transport container number and sample numbers, time, date
Laboratory storage of samples	Laboratory register of storage location, type, temperature, time, date
Sample preparation	Analysis register of sample (laboratory) number, pre-treatment, date, technician
Sample analysis	Analysis register of instrument, calibration, technician, standard method, date, result

6.5 Laboratory Analysis

During laboratory analysis of samples, standard laboratory analytical procedures are employed and all analyses are undertaken by laboratories with NATA-accredited methods.

6.6 Quality Control Samples

Replicate samples will be collected and submitted to the laboratory for analysis as described in **Sections 5.2.3.1** and **5.3.5**. The results for the replicate samples will be compared against the corresponding routine samples and any potential quality control issues will be discussed with the laboratory.

7 Data Analysis and Management

The proposed method in this WQMP for inferring something from the monitoring results is based on the *Australian and New Zealand guidelines for fresh and marine water quality - Volume 1* (ANZECC ARMCANZ, 2000a) and the *Australian guidelines for water quality monitoring and reporting* (ANZECC ARMCANZ, 2000b). The Water Quality Guidelines (ANZECC ARMCANZ, 2000a) advocates that for physical and chemical (non-toxicant) parameters, the median quality values of fresh and marine waters should be lower than the 80th percentile of concentration values of a suitable reference site (above the 20th percentile for parameters such as dissolved oxygen where low values are the problem). Thus the 80th and 20th percentiles from the baseline monitoring (pre-construction monitoring) have been adopted in this WQMP as trigger values.

The pre-construction monitoring data provides an indication of baseline conditions and the degree of variation for a range of water quality parameters. This provides the initial baseline data for comparison with the construction / operational sampling results. However, it is noted there will likely be different climatic factors such as rainfall and drought and potentially land use changes across the project stages that will produce variations from the baseline data, particularly in respect to surface water quality data. Therefore, the baseline data for surface water quality from the pre-construction stage shall be supplemented with data collected from upstream monitoring locations over the construction and operational stages to provide a more robust baseline data set.

For comparative purposes, relevant ANZECC criteria for surface water quality and groundwater quality are provided in **Appendix K** of this WQMP.

7.1 Surface Water

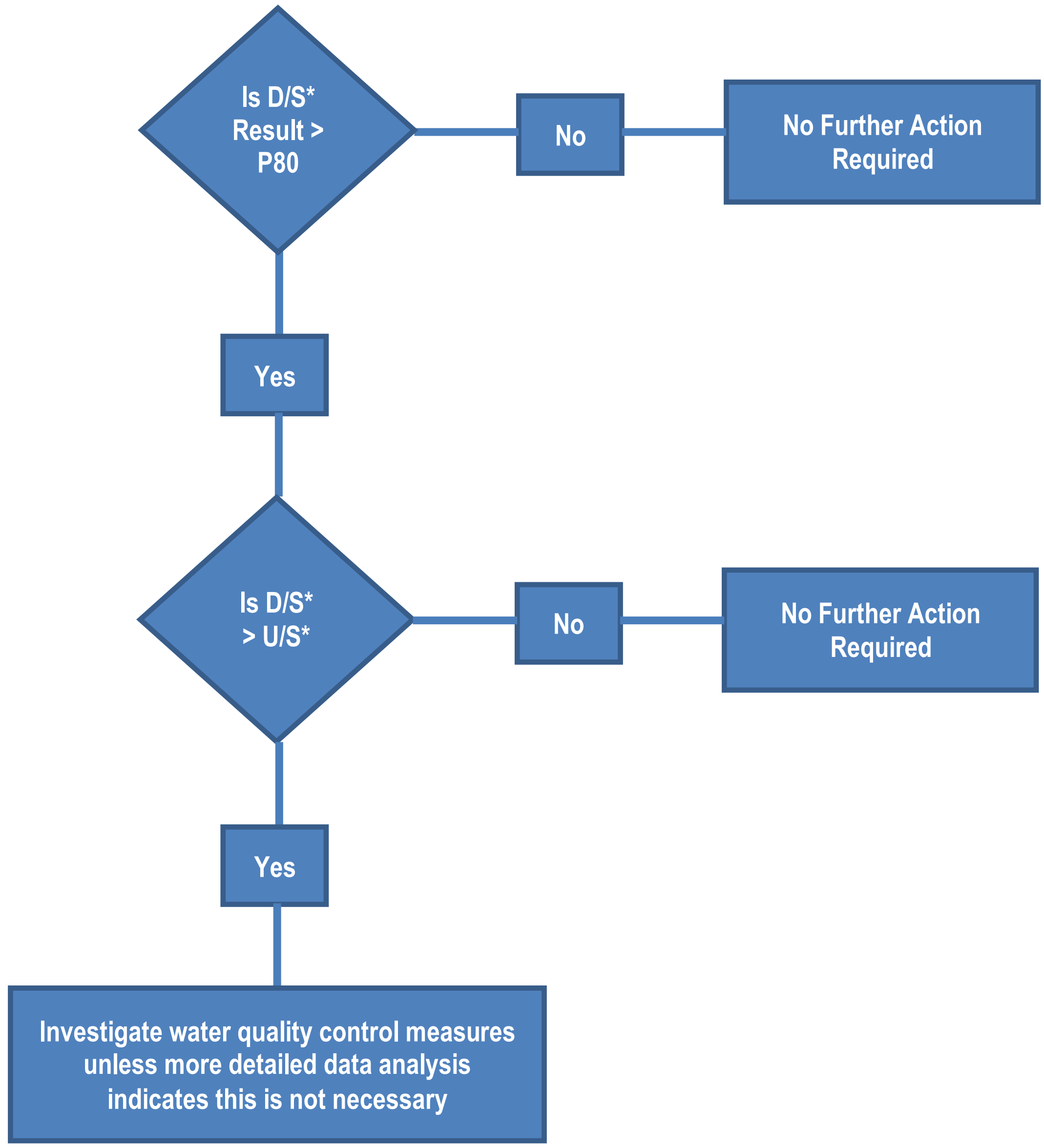
7.1.1 Comparison of Sampling Data and Baseline Data

Comparison of sampling data with baseline data will utilise 80th percentile values from baseline data for trigger values (ANZECC ARMCANZ, 2000b:6-17) and comparison of upstream and downstream data at each sampling location.

The following approach, which is represented in the flow chart in **Figure 7.1**, shall be adopted when assessing surface water quality data collected for each sampling event during the construction and operational phases:

- Compare each downstream construction / operational sampling result with the corresponding 80th percentile figure (P80 figures) from the baseline data (see **Note 1** further below regarding the use of P20 figures for some parameters):
  - Compare dry event sampling results with the P80 for dry events, and wet event sampling results with the P80 for wet events;
  - If a downstream sampling result is greater than the corresponding P80 baseline figure (or less than the corresponding <u>P20</u> baseline figure for DO), this highlights a possibility of the highway impacting on surface water quality requiring further investigation as per the following steps (refer also to example control chart in **Figure 7.2**);
  - If a downstream sampling result is less than the corresponding P80 baseline figure then no further action is required with respect to the subject parameter.
- If a downstream result is greater than the P80 baseline figure (or less than the <u>P20</u> figure for DO) then compare the downstream and upstream sampling results at that location for that event:
  - If a downstream sampling result is less than the upstream result then no further action is required with respect to the subject parameter (see **Note 2** further below with respect to DO, pH and EC).

– If the downstream sampling result is greater than the upstream result then investigate existing water quality control measures unless more detailed analysis of data indicates this is not necessary.



Note: D/S = Downstream; U/S = Upstream

Figure 7.1 Flow Chart for Comparing Surface Water Sampling Data and Baseline Data

Note 1: 20th percentile figure (P20 figures) should be utilised for the following parameters:

- Dissolved Oxygen (DO) – utilise P20 figures instead of P80 figures;
- pH – utilise both P80 and P20 figures.
- Temperature – no comparison required; and
- Electrical Conductivity (EC) – utilise both P80 and P20 figures.

Note 2: for DO, pH, temp. and EC, the following lists the criteria for further investigation when comparing the downstream and upstream sampling results:

- Dissolved Oxygen (DO) - if the downstream sampling result is less than the upstream result, this highlights a possibility of the highway impacting on surface water quality requiring investigation of existing water quality control measures unless more detailed analysis of data indicates this is not necessary. If a downstream sampling result is greater than the upstream result then no further action is required with respect to DO
- pH and Electrical Conductivity (EC) – if the difference between the downstream and upstream sampling results is greater than the standard deviation (Std Dev) from the baseline data, this highlights a possibility of the highway impacting on surface water quality requiring investigation of existing water quality control measures unless more detailed analysis of data indicates this is not necessary. If the difference is less than the standard deviation then no further action is required with respect to the subject parameter
- Temperature – no comparison required.

The technique for comparing sampling results and baseline data / trigger values will use either tabulated results or control charts (or a combination of both). An example of the use of control charts for the comparison of downstream sampling results with the corresponding 80th percentile figure (P80 figures) from the baseline data is shown in **Figure 7.2**. Here, the monthly results for a test parameter for a monitoring location are graphed in a control chart. The results at the downstream or 'impact' site are compared to the trigger value (P80 figures) from the baseline data. It is noted that the baseline data shall be continually adjusted / supplemented with data collected from upstream monitoring locations over the construction and operational stages.

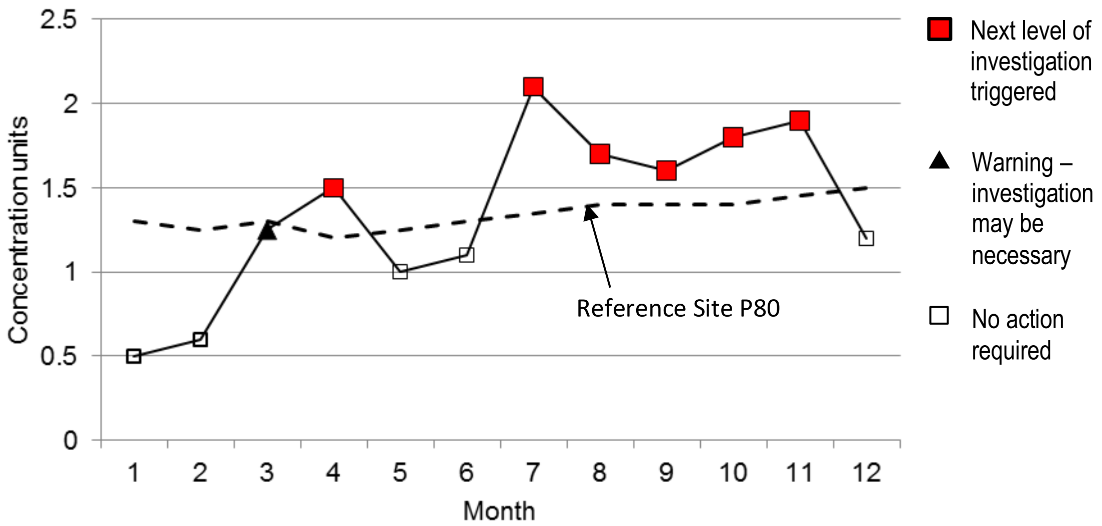


Figure 7.2 Example Control Chart

7.1.2 Adding to Surface Water Quality Baseline Data

The baseline data for surface water quality established from the pre-construction monitoring period will be supplemented with the upstream monitoring data collected during the construction and operational phases of the project. The upstream monitoring sites represent sites not impacted by the highway upgrade and therefore reflect 'baseline' data. This process will provide a more robust set of baseline data over the course of the project.

The baseline data shall be supplemented with the upstream monitoring data on a:

- Monthly basis during the construction phase; and
- Six-monthly basis during the operational phase.

7.2 Groundwater Quality

The following approach, which is represented in the flow chart in **Figure 7.3**, shall be adopted when assessing groundwater quality data collected for each sampling event during the construction and operational phases:

- Compare each construction / operational sampling result with the corresponding 80th percentile figure (P80 figures) from the baseline data (see **Note 1** further below regarding the use of P20 figures for some parameters):
  - If a sampling result is greater than the corresponding P80 baseline figure, this highlights a possibility of the highway impacting on groundwater quality requiring investigation of existing water quality control measures and other potential influences not associated with the highway works unless more detailed analysis of data indicates this is not necessary ;
  - If a sampling result is less than the corresponding P80 baseline figure then no further action is required with respect to the subject parameter.

Note 1: 20th percentile figure (P20 figures) should be utilised for the following parameters:

- Dissolved Oxygen (DO) – utilise P20 figures instead of P80 figures;
- pH – utilise both P80 and P20 figures.
- Temperature – no comparison required;
- Electrical Conductivity (EC) – utilise both P80 and P20 figures;
- Total Dissolved Solids (TDS) – utilise both P80 and P20 figures.

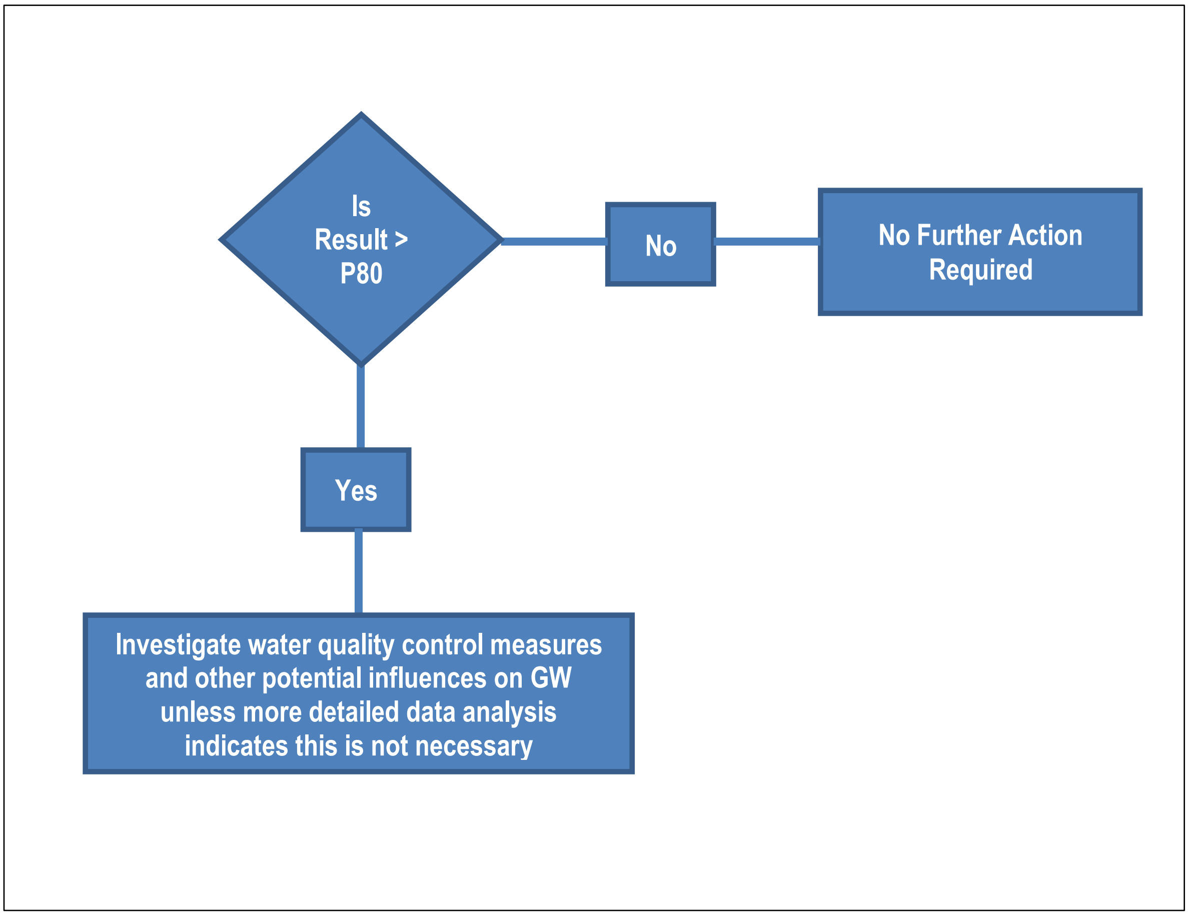


Figure 7.3 Flow Chart for Comparing Groundwater Sampling Data and Baseline Data

7.3 Groundwater Levels

The following approach, which is represented in the flow chart in **Figure 7.4**, shall be adopted when assessing groundwater level data collected for each downloading event during the construction and operational phases:

1. For each cutting site, compare the relative difference between the groundwater levels on either side of the cutting with the P80 baseline figure:
   - If the relative difference is less than the corresponding P80 baseline figure then no further action is required with respect to the subject cutting site.
   - If the relative difference is greater than the corresponding P80 baseline figure, this highlights a possibility of the highway cutting impacting on groundwater flows requiring further investigation as per the following steps
2. If relative difference is greater than the corresponding P80 baseline figure then further assess the groundwater level data to determine if the difference is due to 'natural' variations having consideration of:
   - The timing of the cutting excavation works at the specific site;
   - Site observations that indicate interception of groundwater levels;
   - Climatic conditions such as rainfall / extended dry period which may influence one of the groundwater bores more than the other;
3. If the above assessment (Points 1 & 2) indicates the difference is due to 'natural' variations then no further action is required.
4. If it is unclear from the above assessment (Points 1 & 2) as to whether the difference may be due to 'natural' variations or the highway works, then: monitor / download the groundwater levels on a quarterly basis at the subject cutting site and repeat the above process for each downloading event. Revert back to original monitor / download frequency if it is determined the difference is due to 'natural' variations;
5. If the above assessment (Points 1 & 2) indicates the difference is due to the highway works then investigate existing groundwater control measures and investigate additional mitigations as required.

7.4 Data Interpretation

After the data analysis, the results will be collated into a concise statistical summary and assessed in the context of the monitoring objectives below.

7.4.1 Construction Stage

Data interpretation for the construction stage monitoring will address:

- Surface water quality:
  - refinement of baseline surface water quality data for the project by supplementing pre-construction data with upstream monitoring data;
  - identification of potential impacts of the highway upgrade construction on surface water quality;
  - recommendations for any refinements of construction surface water management measures;
- Groundwater quality:
  - identification of potential impacts of the highway upgrade construction on groundwater quality;
  - recommendations for any refinements of construction groundwater quality management measures;
- Groundwater levels:
  - identification of potential impacts of the highway upgrade construction on groundwater levels;
  - recommendations for any refinements of construction groundwater level management measures.

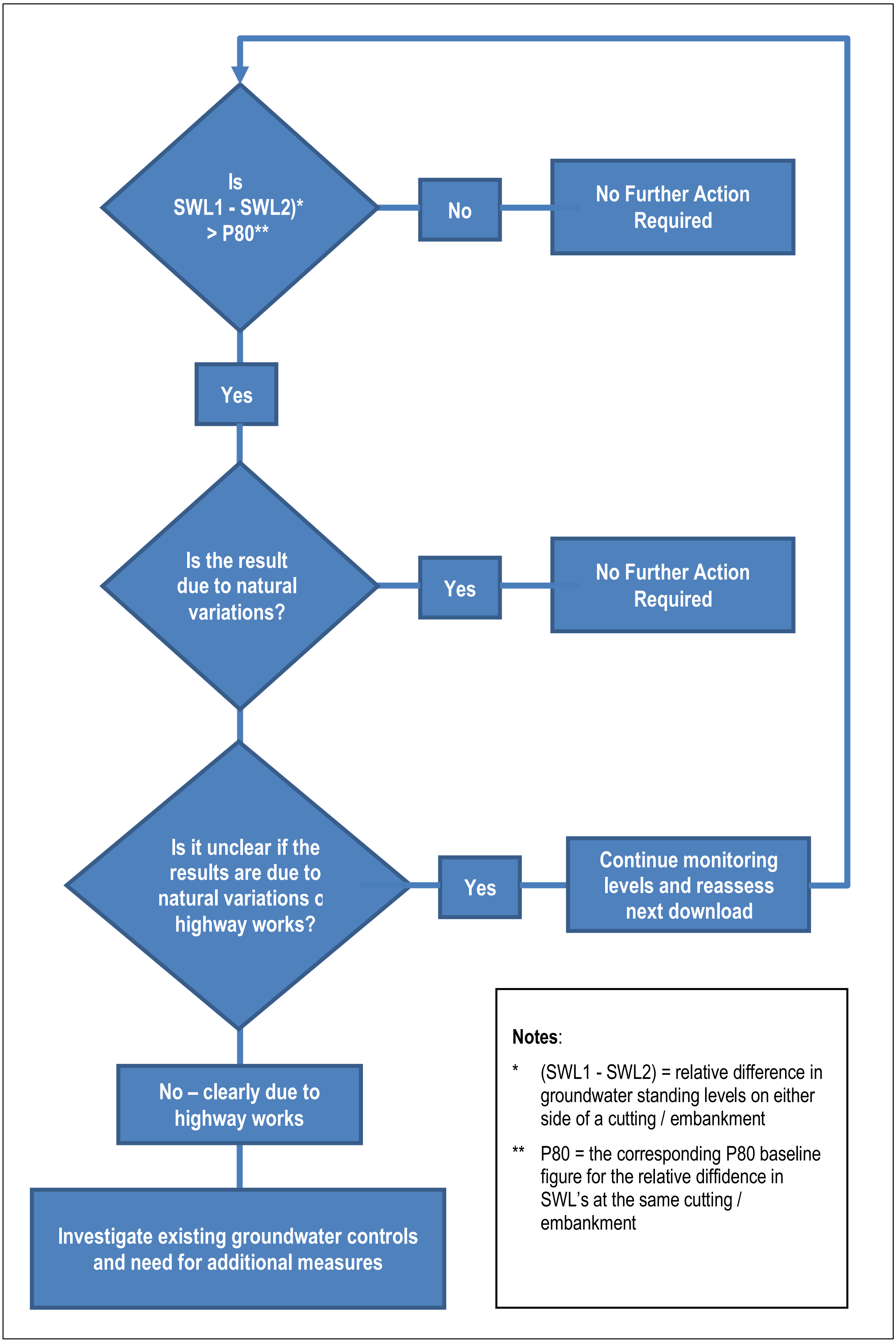


Figure 7.4 Flow Chart for Comparing Groundwater Level Data and Baseline Data

7.4.2 Operational Stage

Data interpretation for the operational stage monitoring will address:

- Surface water quality:
  - refinement of baseline surface water quality data for the project by supplementing pre-construction data with upstream monitoring data;
  - identification of potential impacts of the highway upgrade operation on surface water;
  - recommendations for any refinements of operational surface water management strategies and stabilisation works.
- Groundwater quality:
  - identification of potential impacts of the highway upgrade operation on groundwater quality;
  - recommendations for any refinements of operational groundwater management strategies.
- Groundwater levels:
  - identification of potential impacts of the highway upgrade operation on groundwater levels;
  - recommendations for any refinements of operational groundwater level management measures.

7.5 Reporting

7.5.1 Construction Stage

Reporting during the construction stage will include annual reports and a final report at the completion of the construction stage.

The reports will include any relevant discussion of the results to inform the ongoing management of the surface water and groundwater management measures and the results will be discussed and minuted at the Environmental Review Group meetings.

Annual reports will be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the Minister's Conditions of Approval (MCoA) – refer to **Section 1.2** and **Table 1.1** in this WQMP. Annual reports will include:

- introduction and background: description of the program and objectives and defining the extent of the highway upgrade works;
- experimental detail, describing the sampling regime and parameters including detail of the sampling locations so they can be unambiguously identified, e.g. GPS directions and descriptions of methods of sampling and analysis;
- presentation, interpretation and discussion of the results addressing the items outlined in **Section 7.4**;
- review and recommendations for the monitoring program for the construction and operational stages; and
- appendices, providing laboratory reports, data tables or other relevant information.

Similarly, the final report at the completion of the construction stage will be of a similar format to that outlined above and will include recommendations for the operational monitoring program. The final report will also be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the MCoA.

7.5.2 Operational Stage

Reporting during the operation stage will also include annual reports and a final report at the completion of the first three years of operation.

Annual reports will be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the Minister's Conditions of Approval – refer to **Section 1.2** and **Table 1.1** in this WQMP. Annual reports will be of a similar format to that outlined in **Section 7.5.1**.

Similarly, the final report at the completion of the first three years of operation will be of a similar format to that outlined in **Section 7.5.1** and will also be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the MCoA.

8

Management Actions

This section provides an overview of potential contingency and ameliorative measures that could be implemented in the event that adverse impacts are identified. The following contingency and ameliorative measures are largely based on potential measures outlined in the environmental impact assessment for the project. It is noted that alternative measures may be more suitable. This would be determined when adverse impacts are identified and in full consideration of relevant factors and site specific circumstances.

The development of mitigation measures and specific actions should consider related management plans such as the Threatened Frog Management Plan (RMS *et. al.*, 2014) and Threatened Fish Management Plan (RMS *et. al.*, 2013) to ensure measures are complimentary or to avoid conflicting measures / outcomes. The Contractors environment team involved in soil and water management should also be aware of these related plans.

8.1 Construction Phase - Surface Water Management Actions

The key mitigation measures for the construction stage will be sediment basins and additional erosion and sediment controls to intercept run-off and retain the associated sediments and pollutants. Maintenance and monitoring of these measures by the Contractor will form a key component of the mitigation measures. The measures will address the relevant CoA and the safeguards detailed in the EIS and Submission &/ Preferred Infrastructure Report (SPIR). Construction activities will also be managed to meet water quality objectives in the Environmental Protection Licence (EPL) conditions. The measures will be formulated at the detailed design stage as part of the Construction Soil and Water Management Plan (CSWMP) within the CEMP which will be submitted for approval by the Department of Planning and Environment. The plan will include water quality monitoring at the outlet of the sediment basins. General water quality criteria for discharges from sediment basins will comprise:

- pH between 6.5 - 8.5
- TSS < 50mg/L
- No visible oil and grease.

The measures will integrate with related plans such as the Threatened Fish Management Plan where there may be specific requirements for monitoring or treatment of captured water.

Management actions will also be triggered by assessment of water surface water quality data collected during the construction phase as outlined in **Section 7**. If the sampling results indicate a possibility of the highway impacting on surface water quality (as outlined in **Section 7.1**), the Contractor is to investigate existing water quality control measures to determine any maintenance requirements or additional measures to be implemented at that location.

8.2 Construction Phase - Groundwater Management Actions

Similar to surface water management, some of the key mitigation measures for the construction stage will be construction of erosion and sediment controls. Other measures will include best practice management for siting and bunding of storage areas where appropriate. There will also be site specific measures such as in the drinking water catchment of the Rous Water Woodburn Sands borefield where: the design of the basins may be shallower than standard to avoid penetration of the natural clay layer; and certain construction activities may be restricted such as refueling, washdown, and storage of chemicals. Measures will be formulated at the detailed design stage as part of the CEMP which will be submitted for approval by the Department of Planning and Environment.

The following is a non-prescriptive list of potential contingency and ameliorative measures that could be implemented in the event that adverse impacts are identified:

- Where sites used for stockpiles, washdown, batch plants, refuelling and chemical storage are located in areas of sensitive/shallow water table, best practice management for siting, erosion and sediment controls, and bunding of storage areas in combination should be employed.
- Dewatering of excavations would be undertaken in line with RMS' Technical Guideline – Environmental Management of Construction Site Dewatering (RMS, 2011c), and in accordance with any licence conditions.
- Where groundwater is released, recharge of the water table is the preferred option of managing groundwater. This would be facilitated by collecting groundwater in grassed swales for infiltration back to the groundwater source. Where possible, these swales would divert the groundwater around the construction area so that the groundwater does not further mix with construction runoff. Recharge could also include the collection of seepage from the cut face in the drainage system which would be diverted to absorption trenches or to water quality ponds to be tested and possibly treated before being released back to the creek or natural drainage system at some point downstream. Any diversion of groundwater intercepted during construction activities into existing water quality/sediment basins will consider existing design capacity of the basins and any Environmental Protection License requirements that may be impacted by receipt of additional groundwater.

Management actions will also be triggered by assessment of groundwater water quality and groundwater level data collected during the construction phase as outlined in **Section 7**.

8.3 Operational Phase - Surface Water Management Actions

Permanent water quality management and protection measures would be installed to protect adjacent waterways and sensitive receiving environments such as the Rous Borefield from pollutants generated by operation of the project. These would include:

- Water quality ponds;
- Grassed swales; and

In the event that adverse impacts are identified from the monitoring, the following procedure should be implemented:

- Identify potential pollutant source based on the parameters that were exceeded (eg. sediment for high TSS reading, or fuel spill / leak for high hydrocarbon reading);
- Inspect and rectify water quality ponds and grassed swales in area where adverse impacts are identified. This would include inspection of water quality ponds to assess available water storage capacity, water quality, sediment build-up, structural integrity and debris levels.

8.4 Operational Phase - Groundwater Management Actions

In the event that adverse impacts are identified from the monitoring, the procedures outlined in **Section 8.2** should be implemented.

8.5 Adaptive Management Framework

RMS acknowledges the importance of undertaking environmental management using an adaptive management approach and as such the WQMP will be a working document. Given the nature of environmental monitoring, an adaptive management approach is considered appropriate to deliver an effective monitoring program during construction and operation. Following review of results and data, improvements and refinements of the WQMP may be identified. The monitoring program will be reviewed and updated accordingly based on this ongoing review process in order to provide a robust monitoring framework in response to the CoA requirements.

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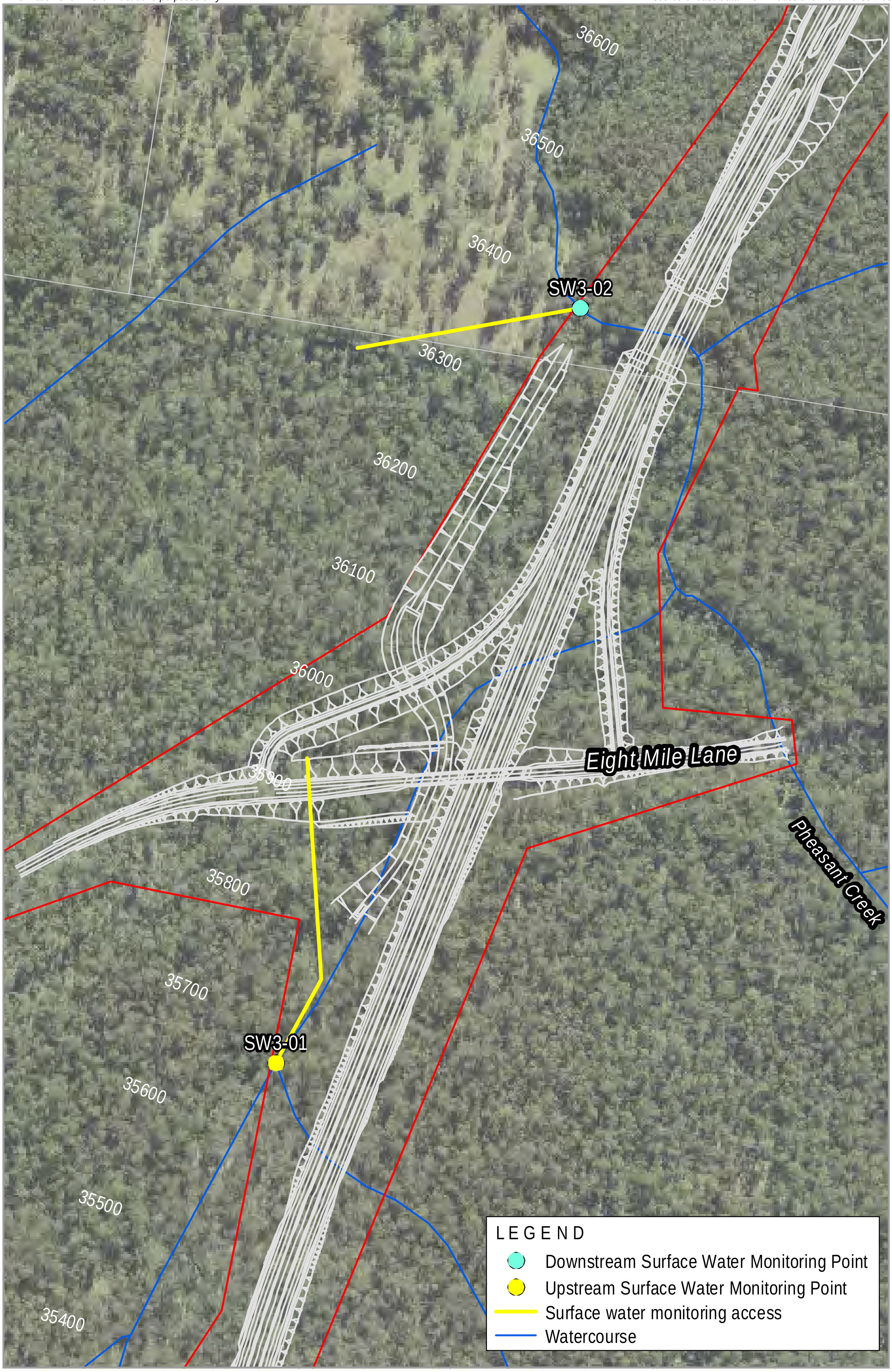
Appendix A

Maps of Monitoring Locations - Surface Water and Groundwater



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Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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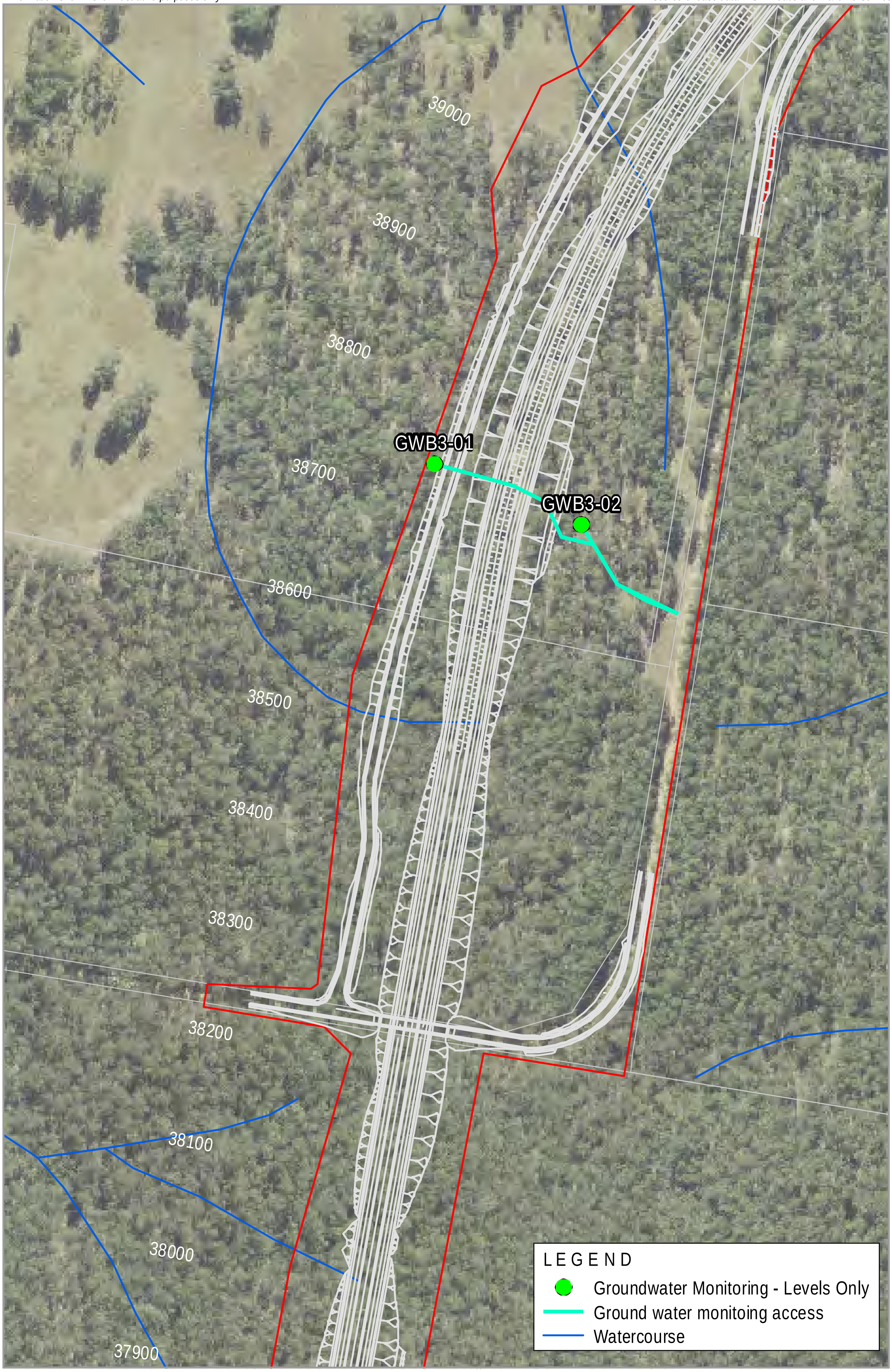

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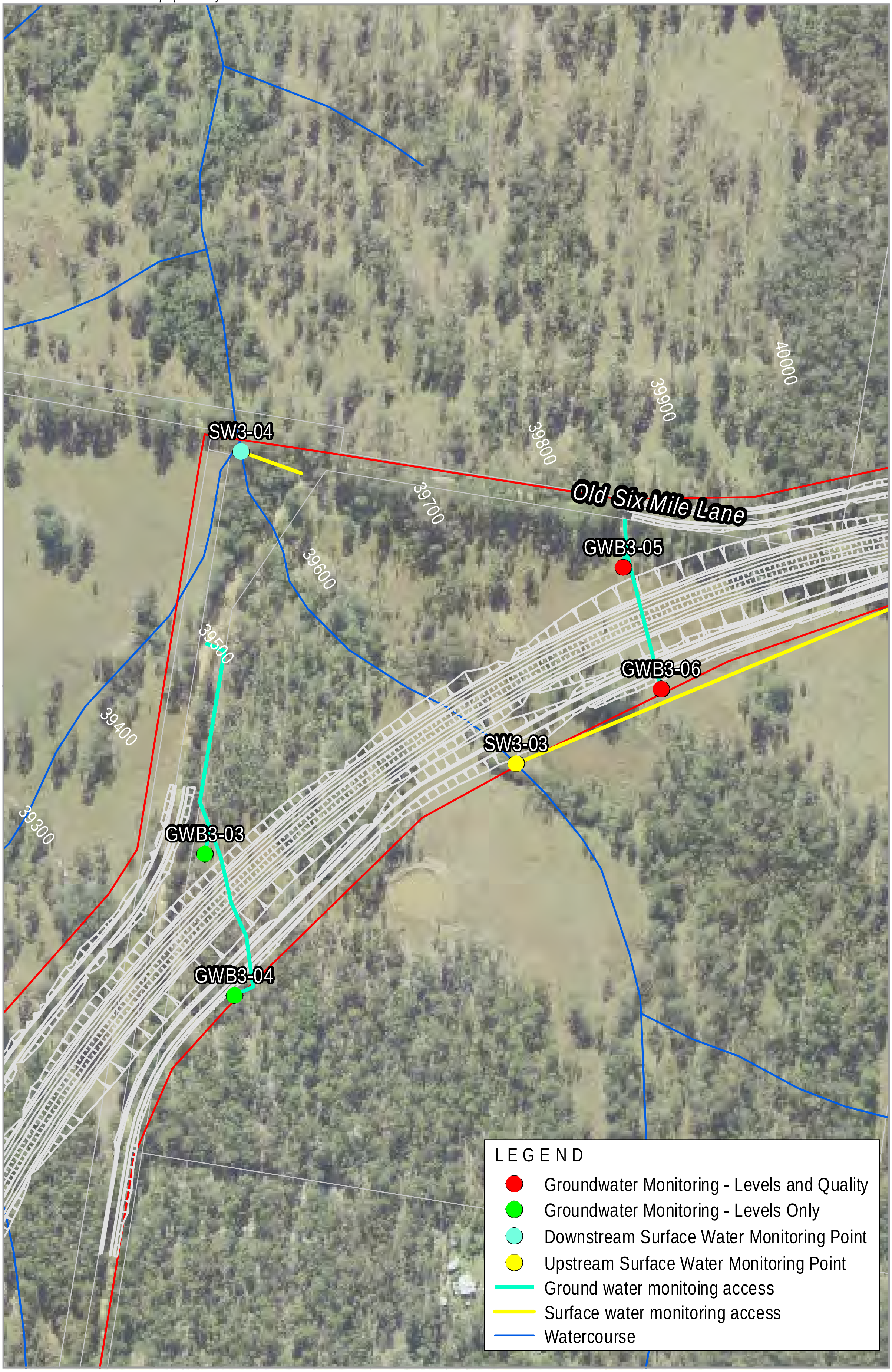

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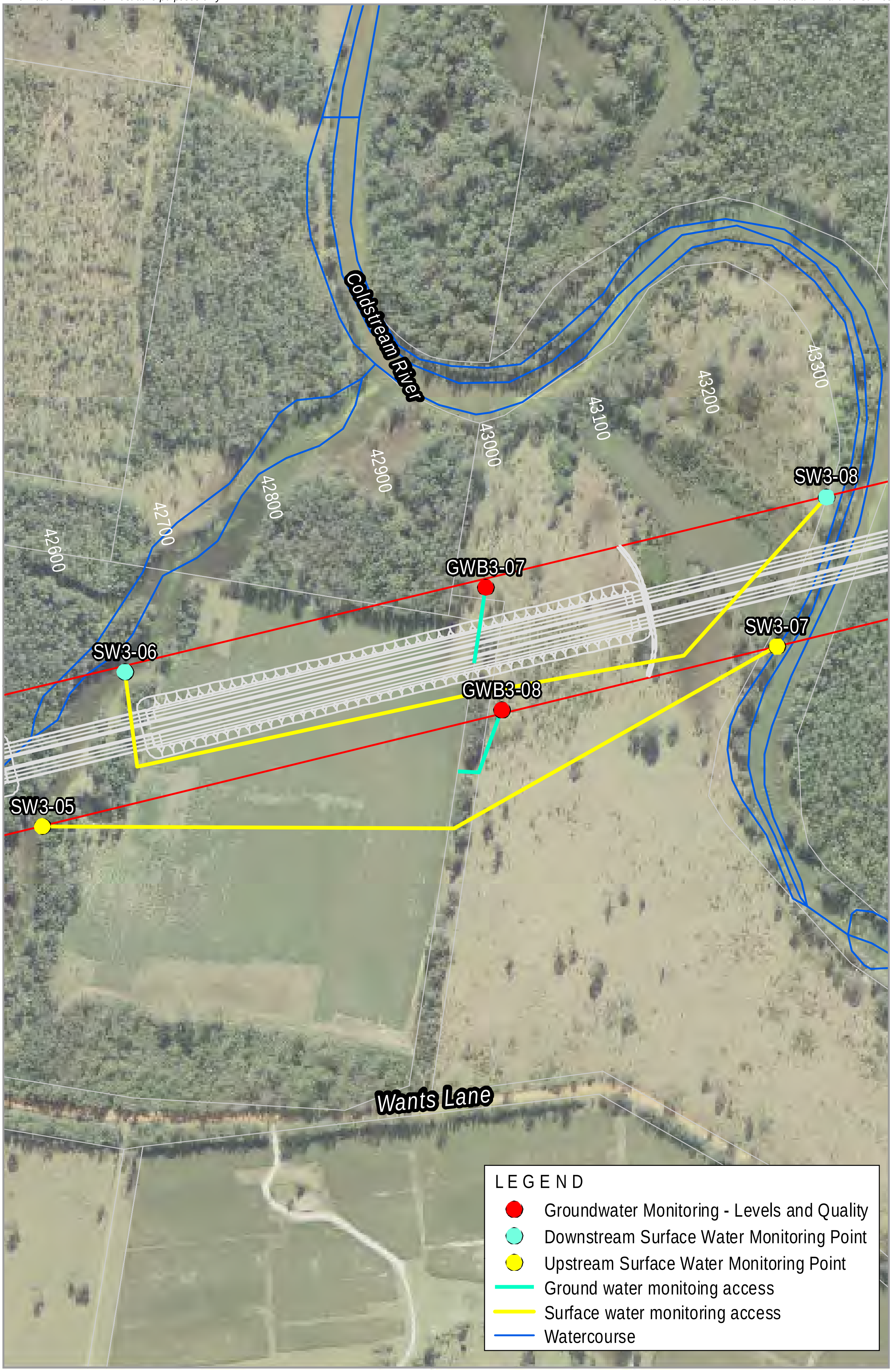

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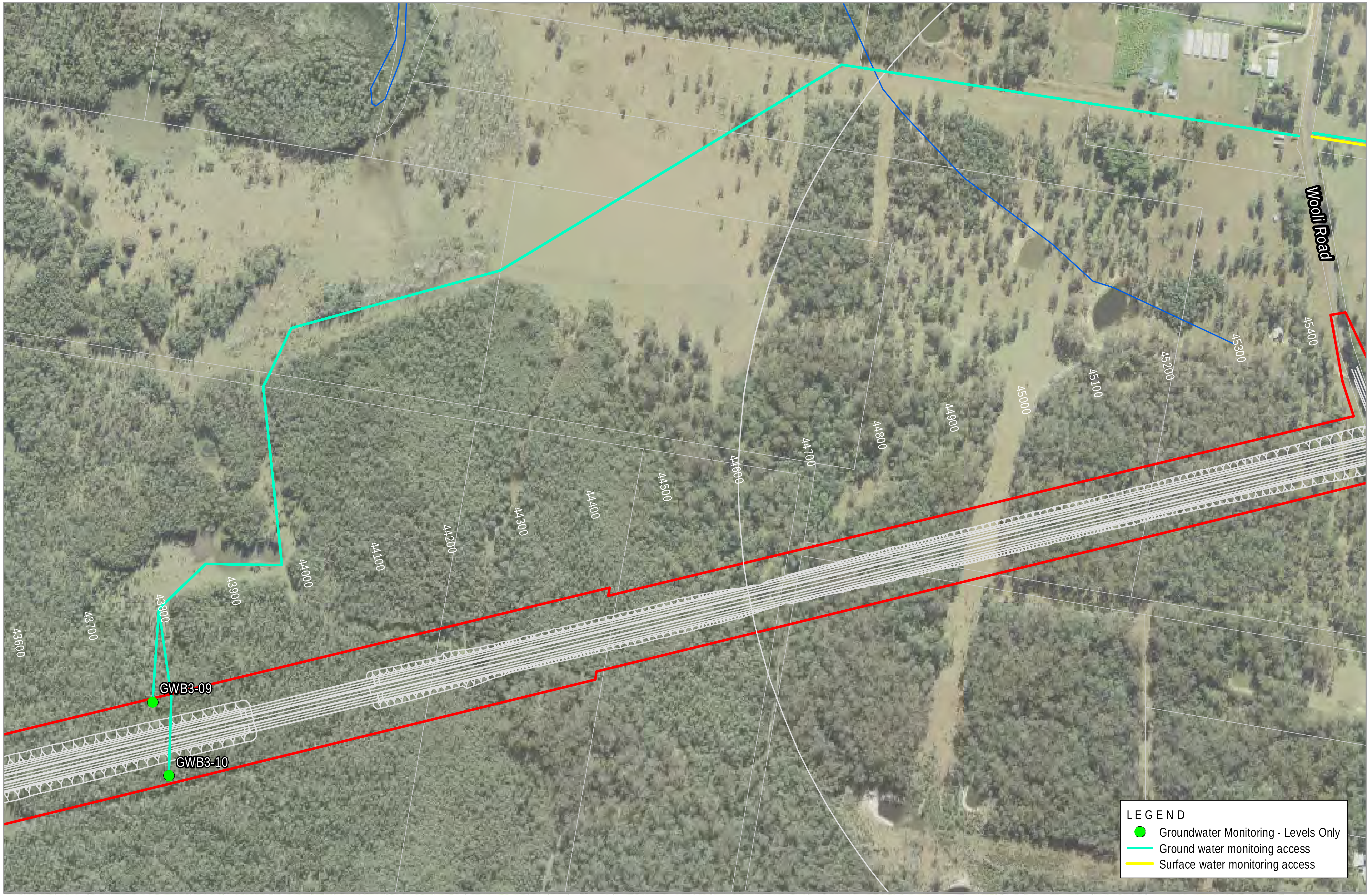

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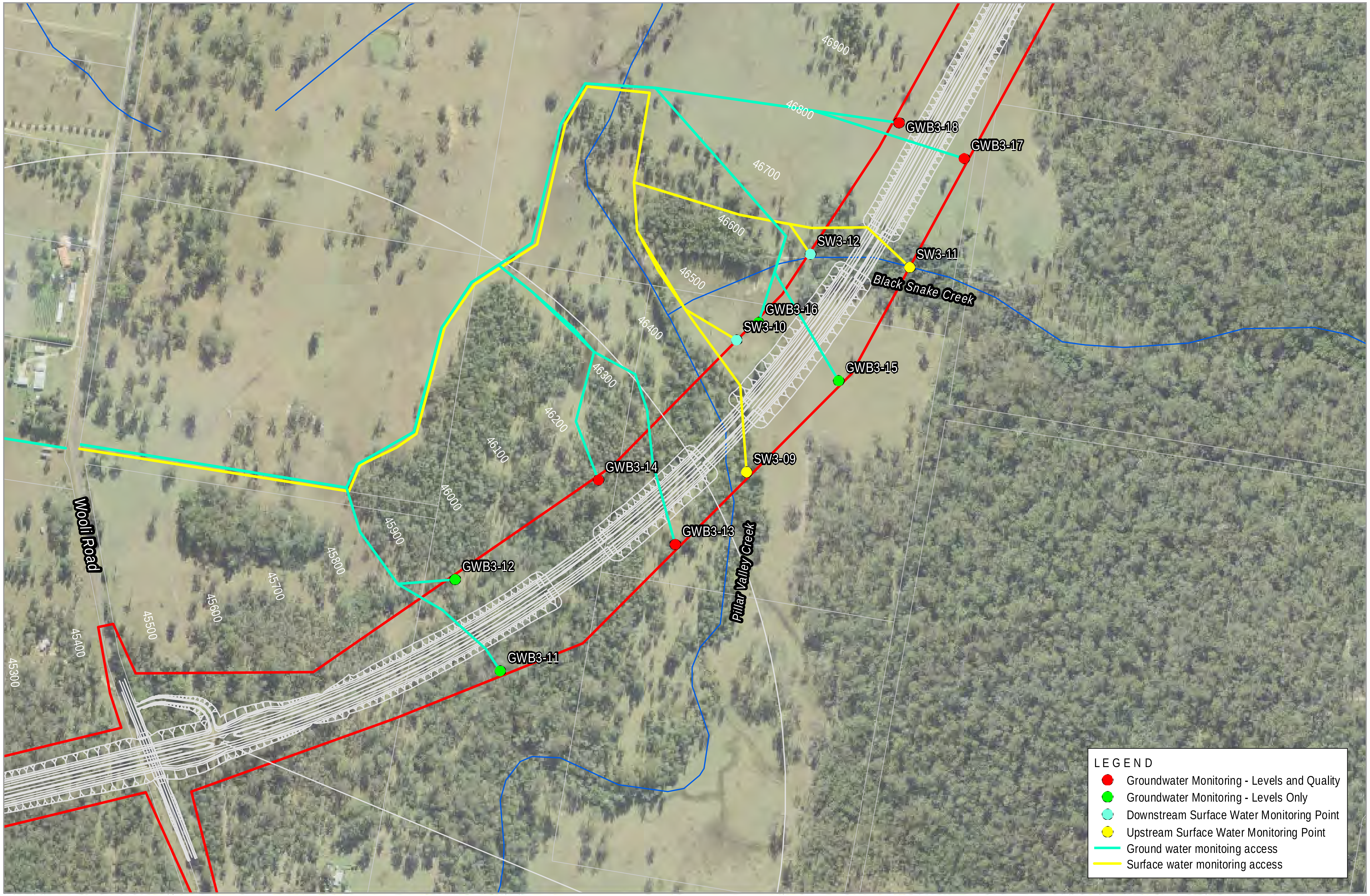

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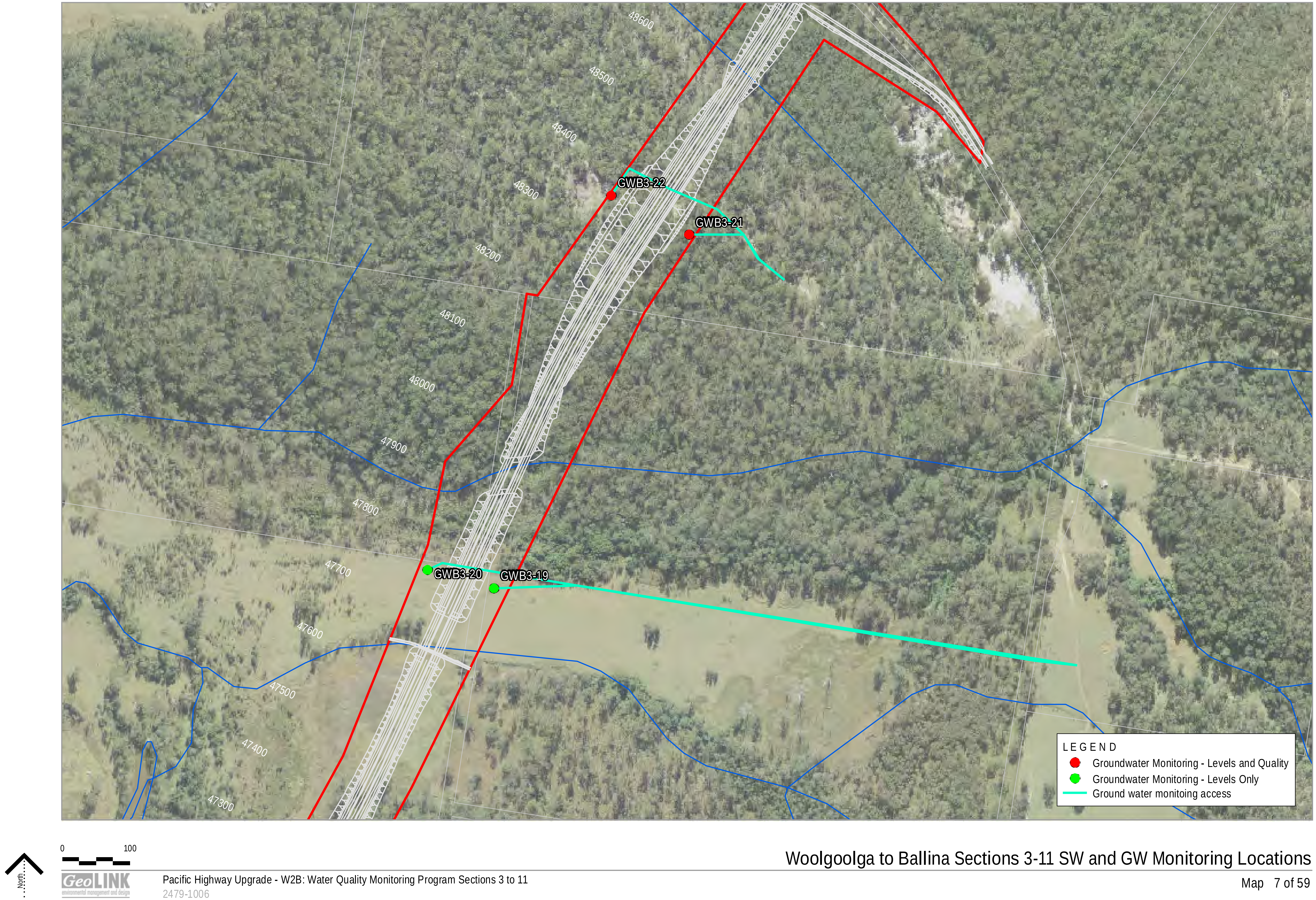

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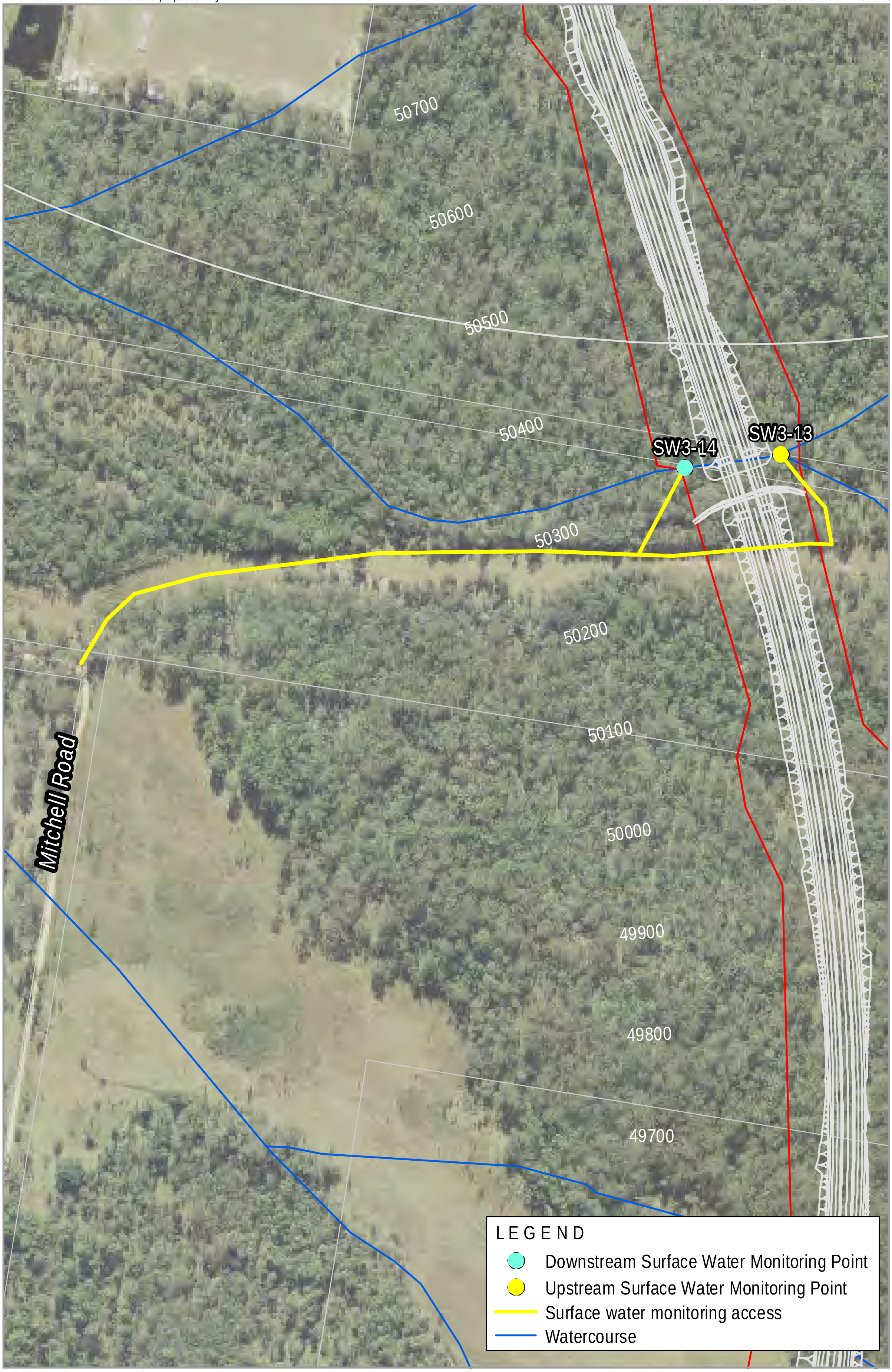

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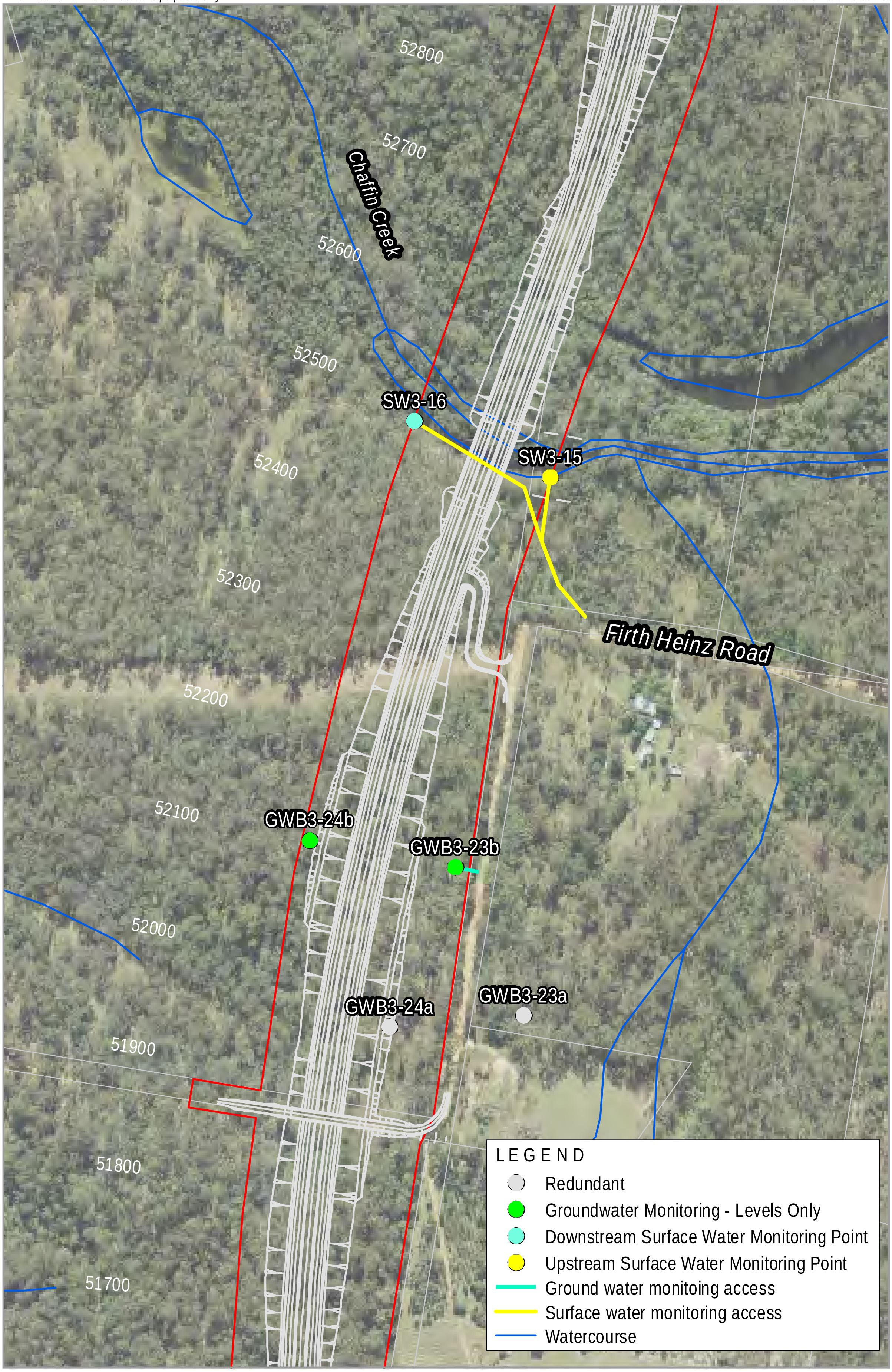

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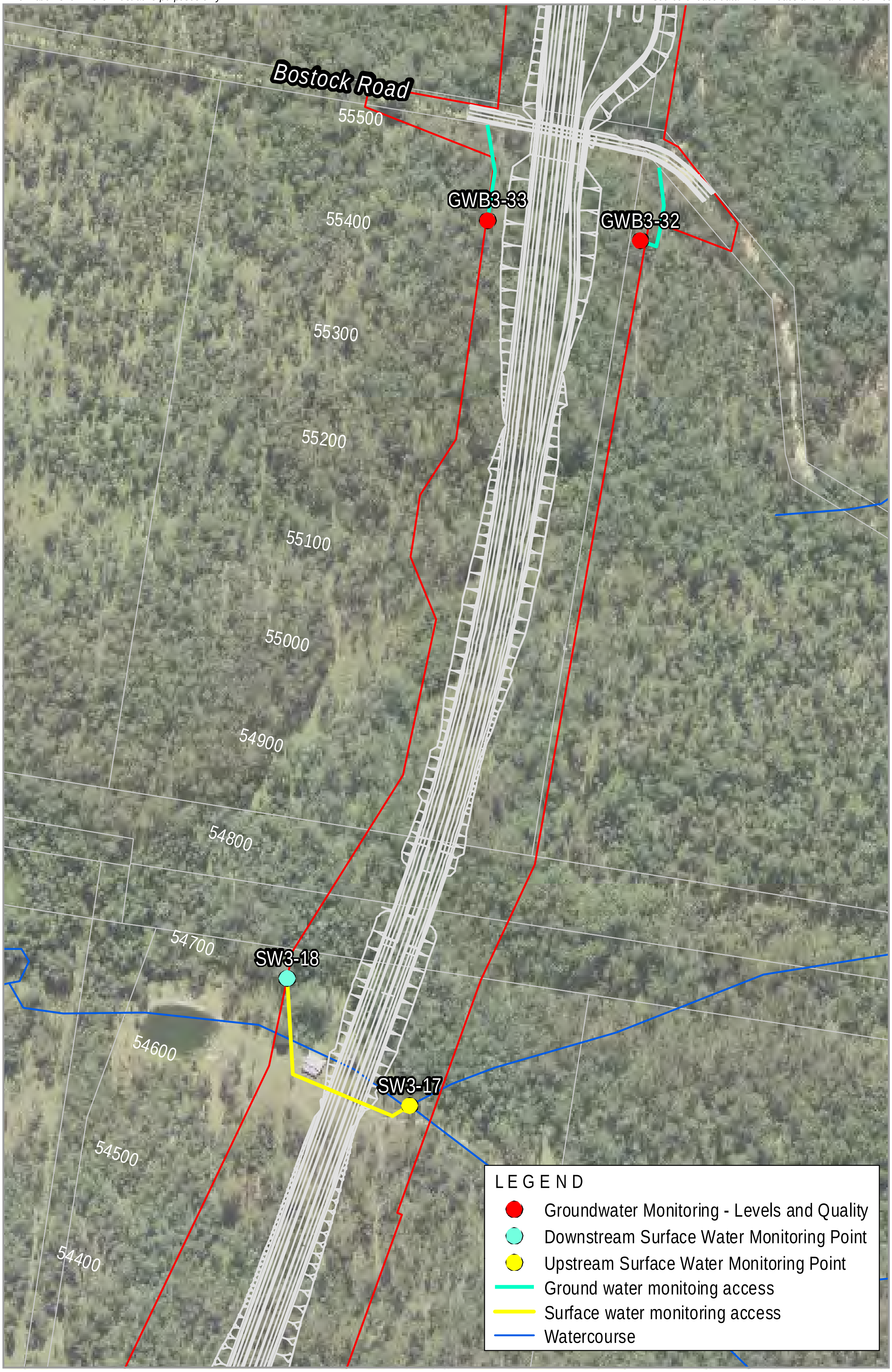

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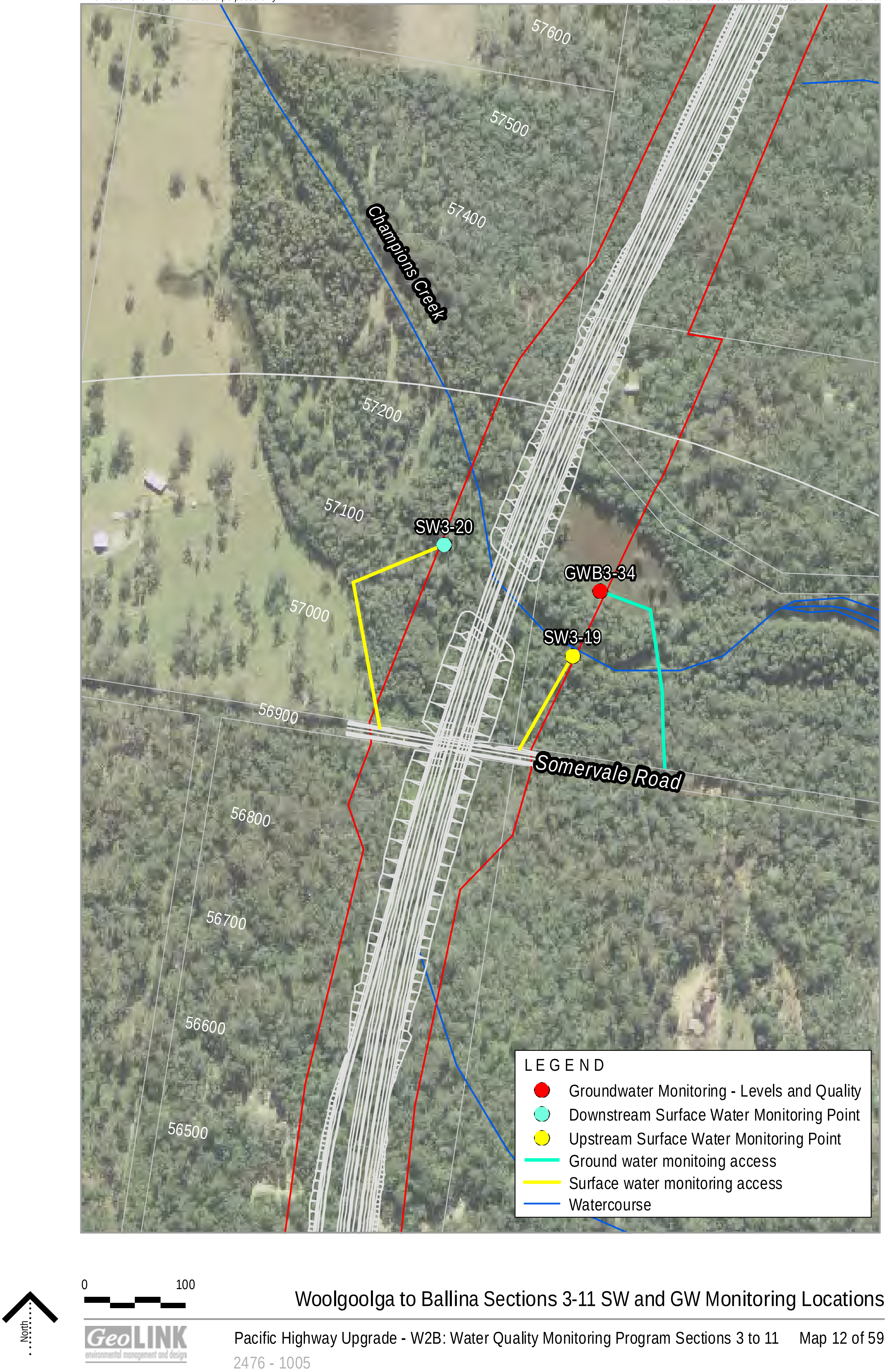

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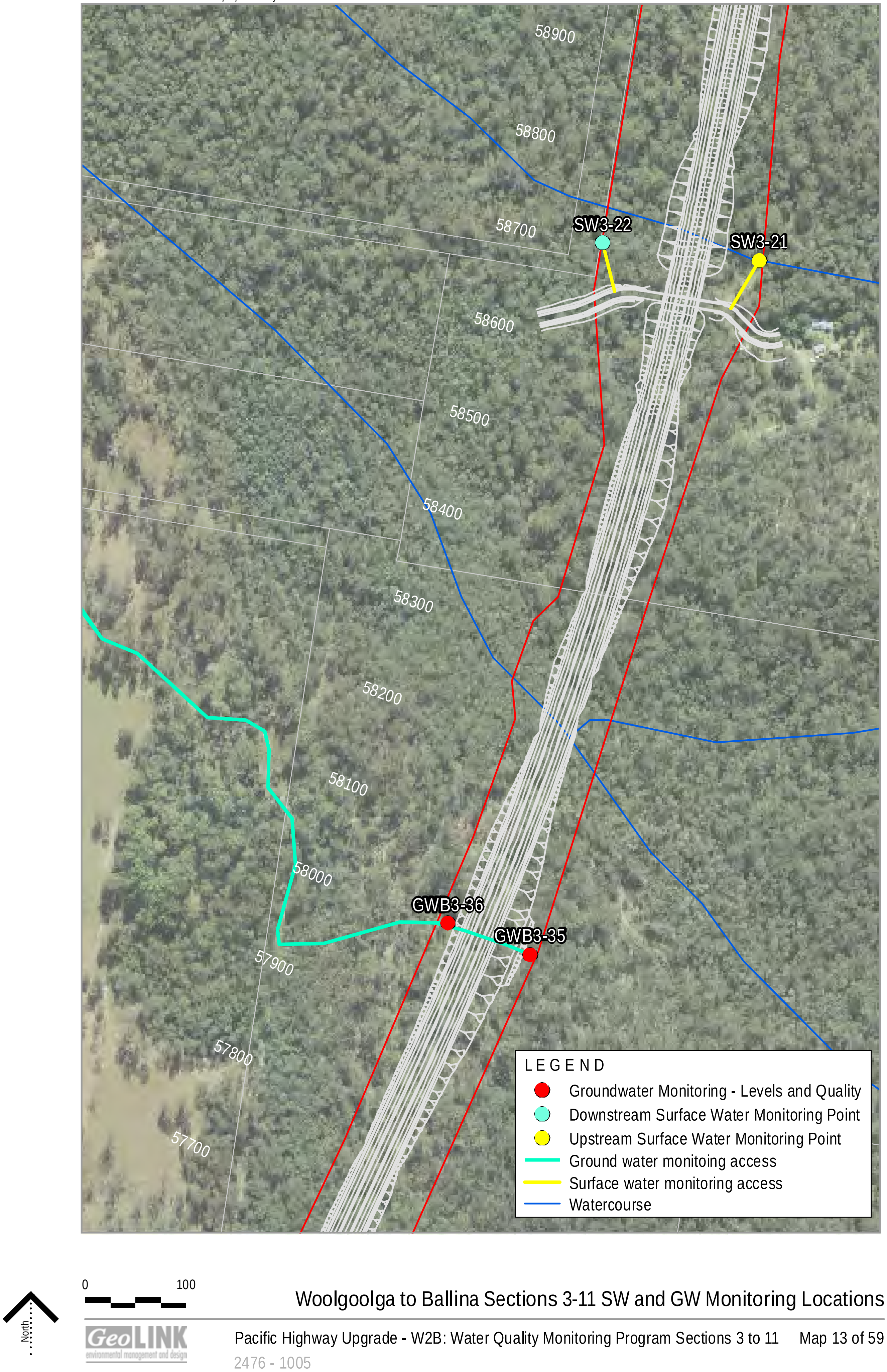

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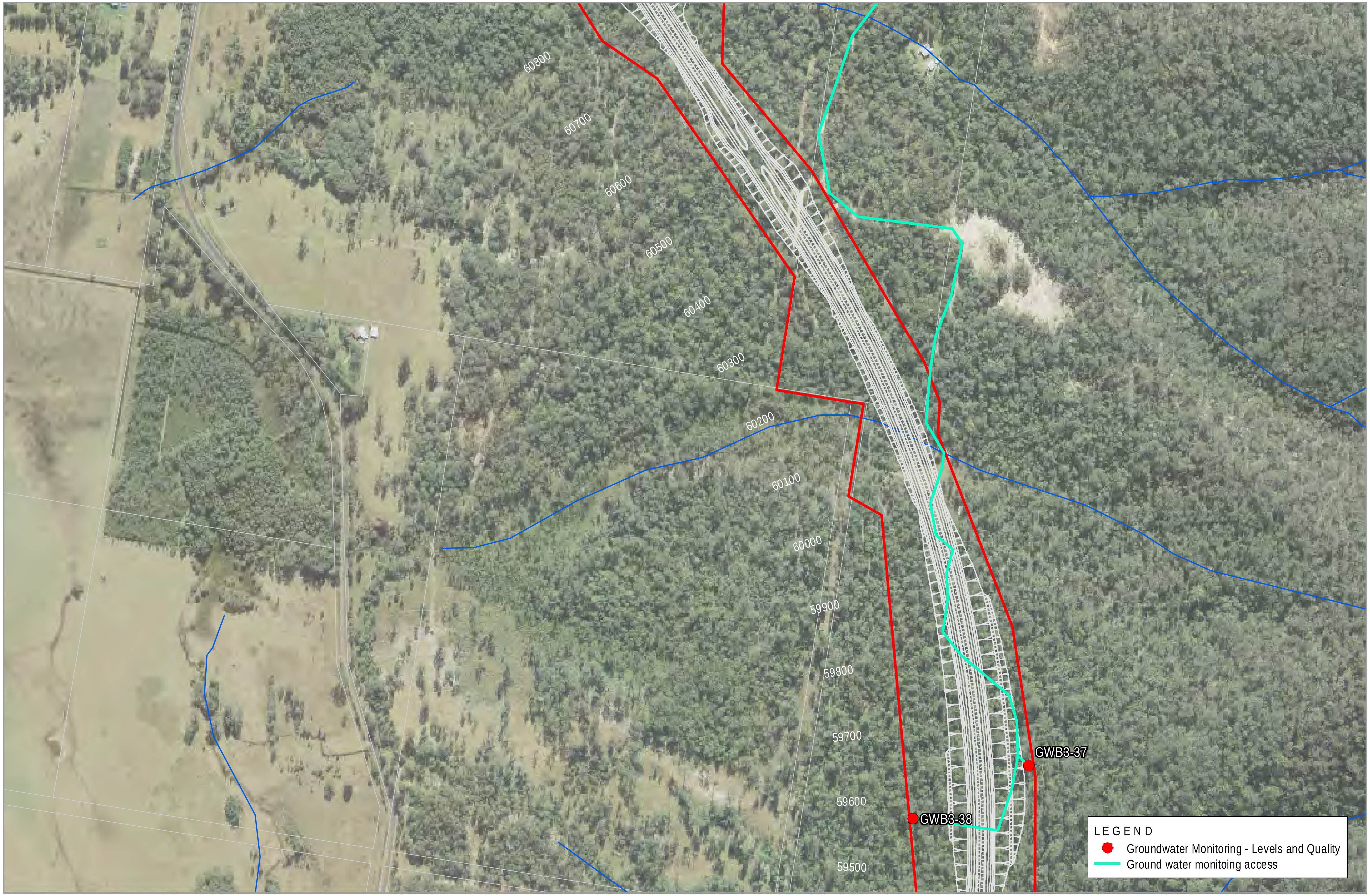

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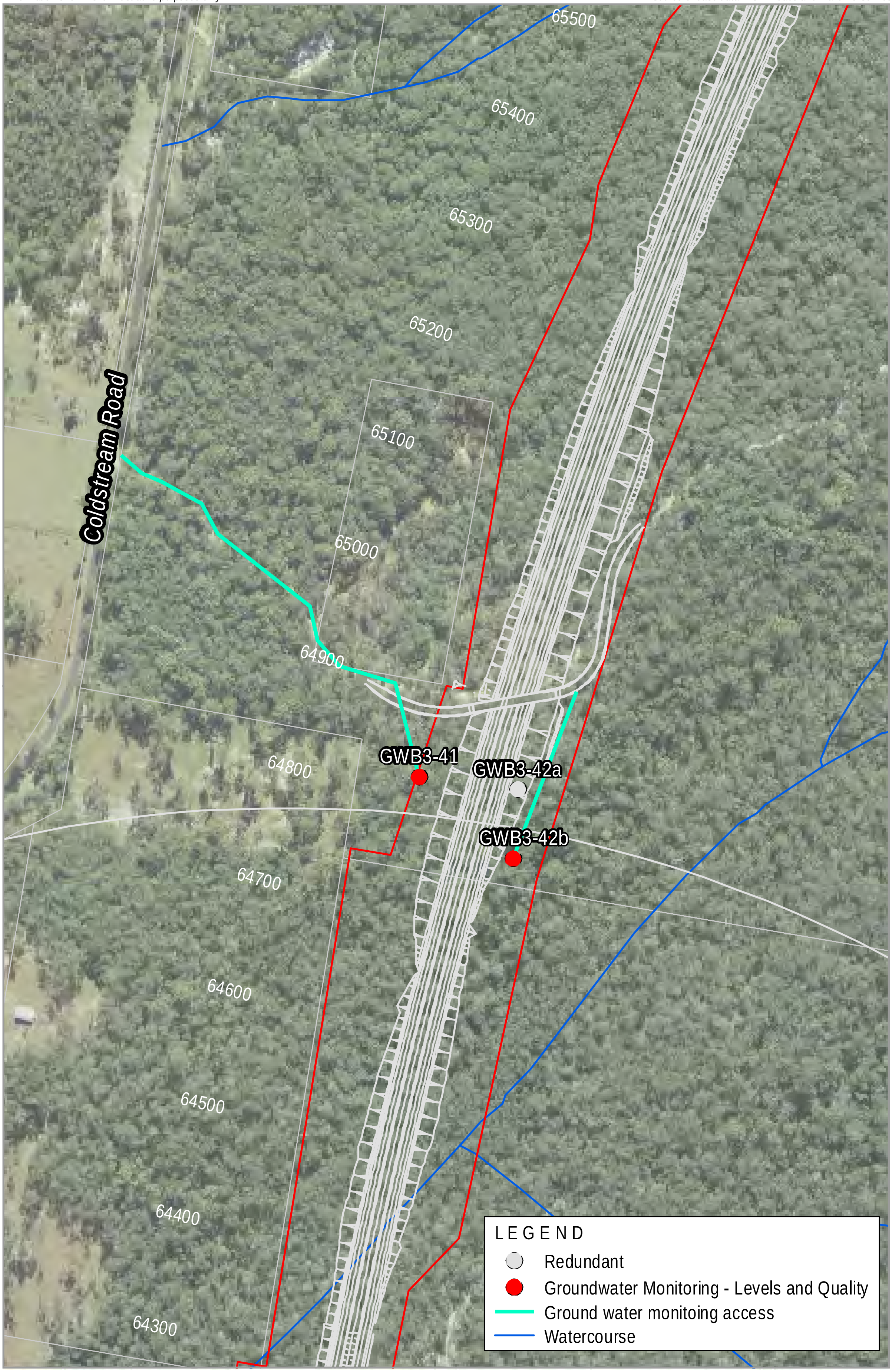

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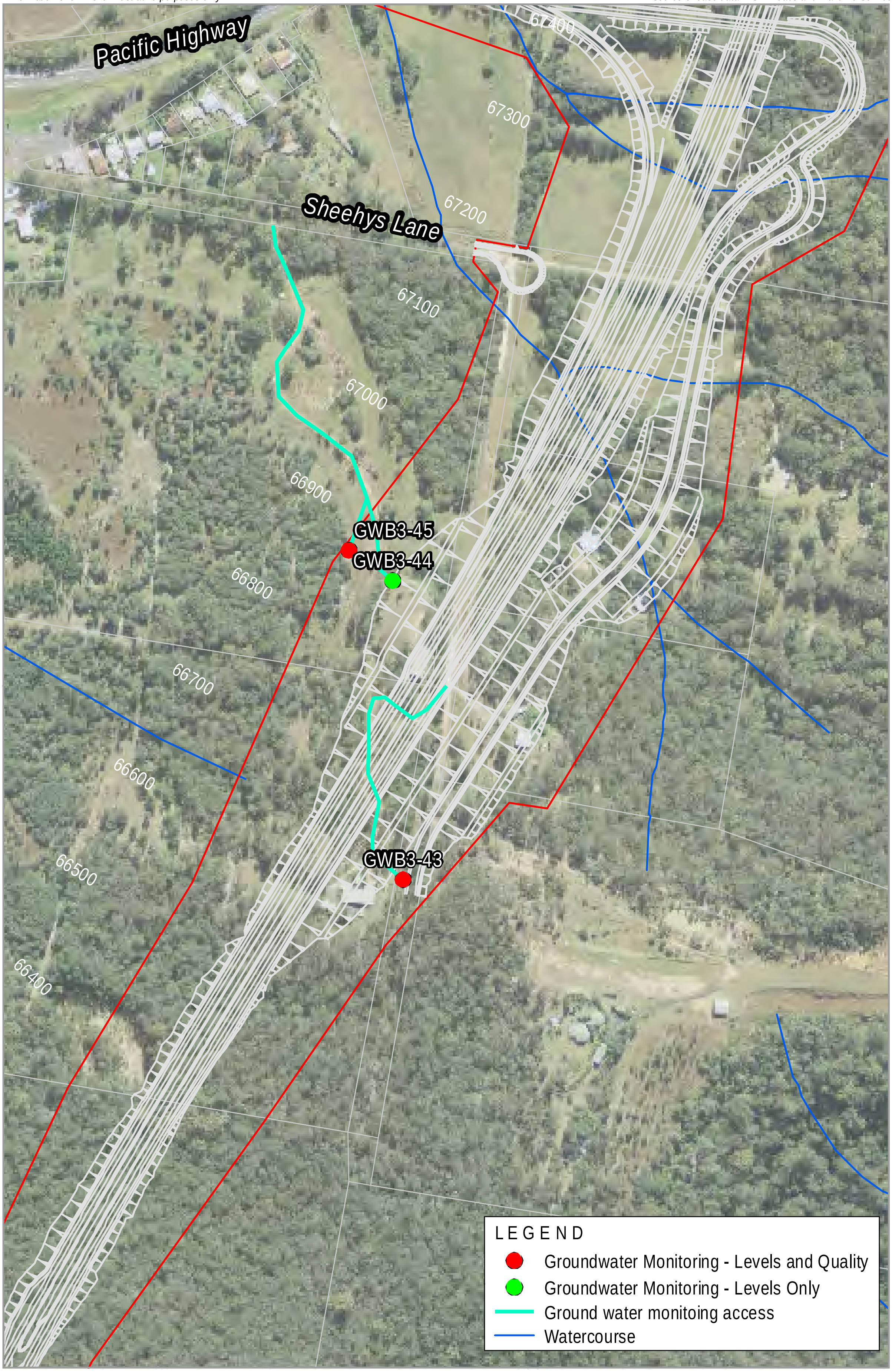

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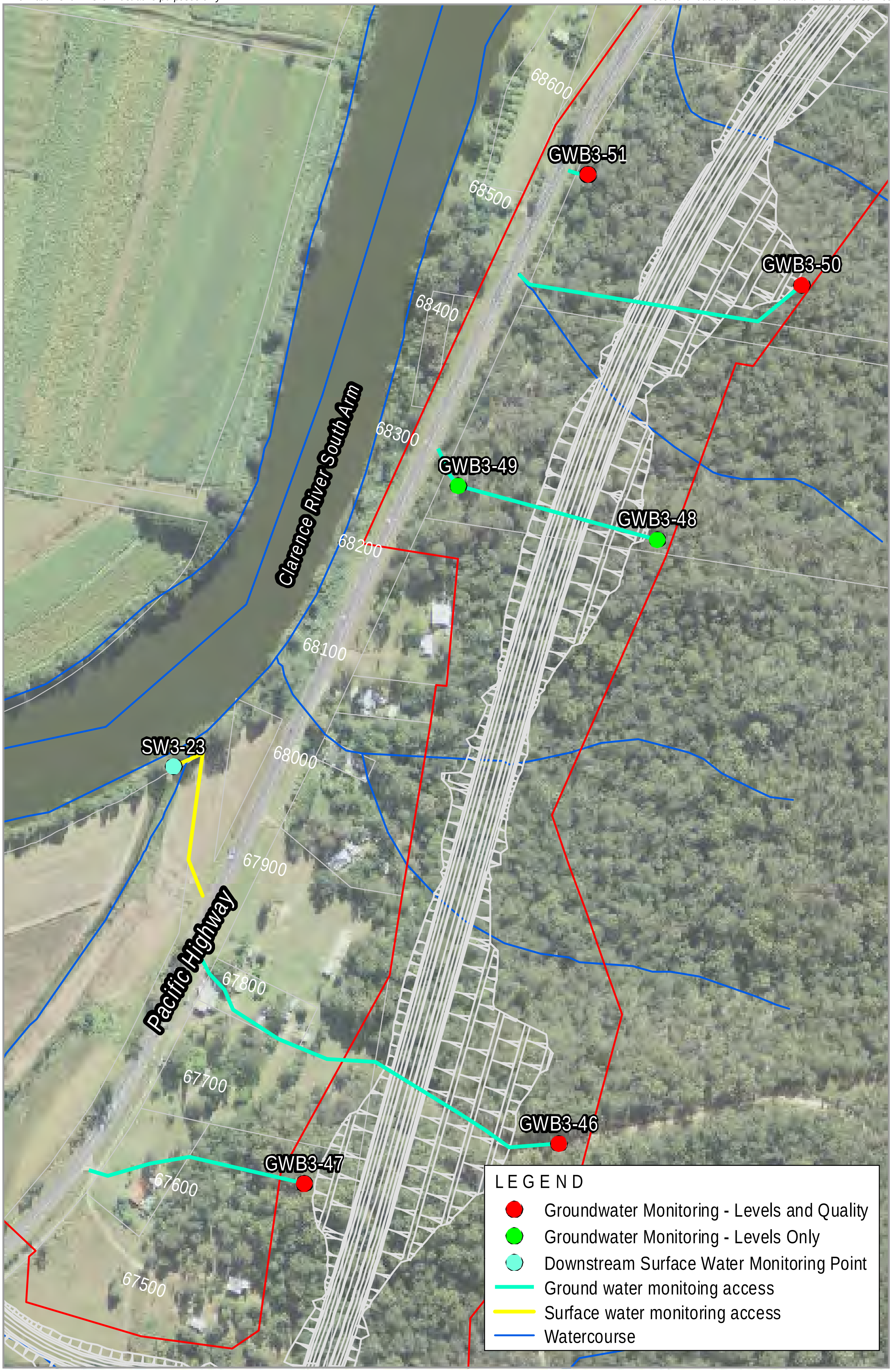

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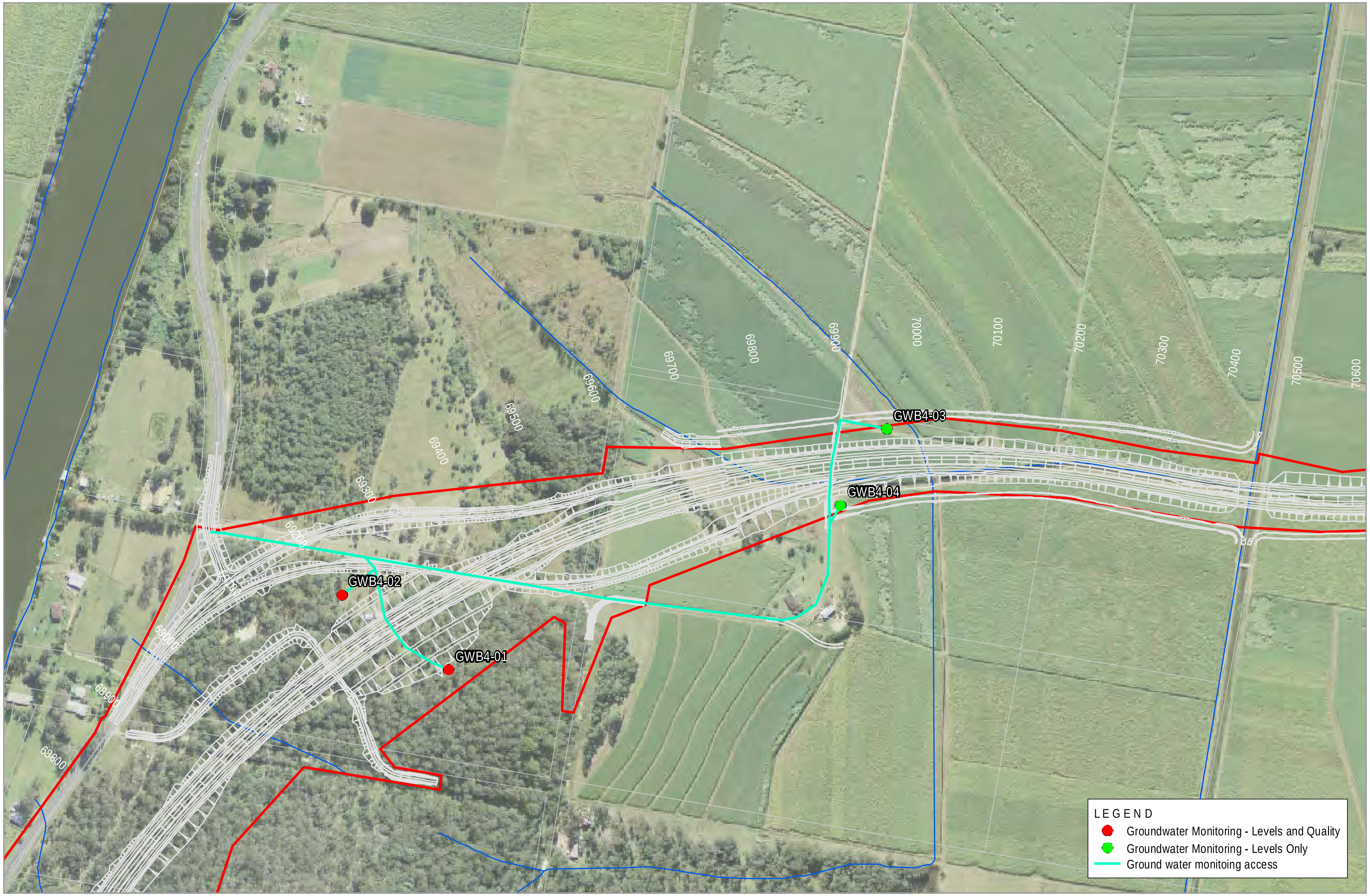

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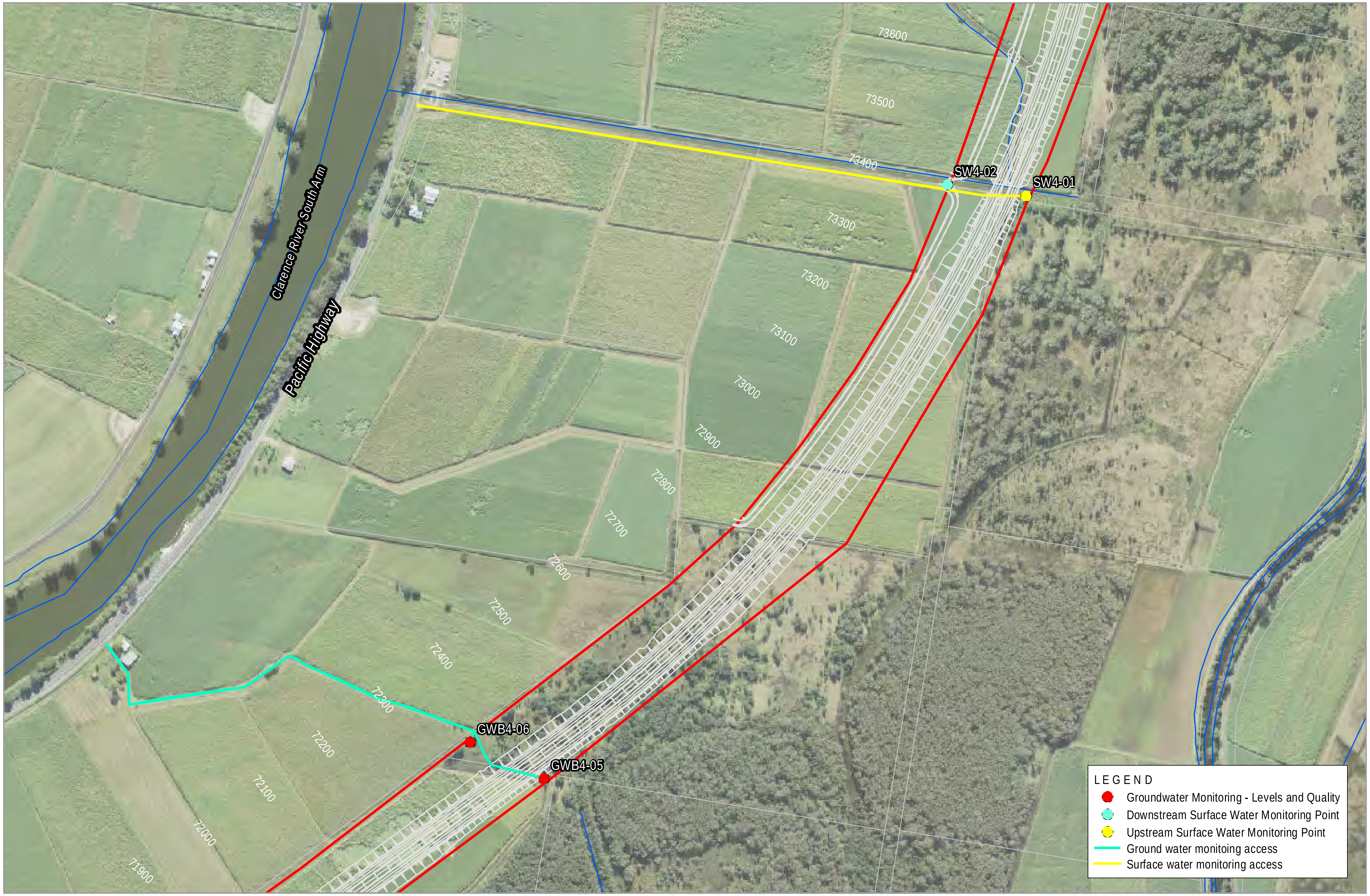

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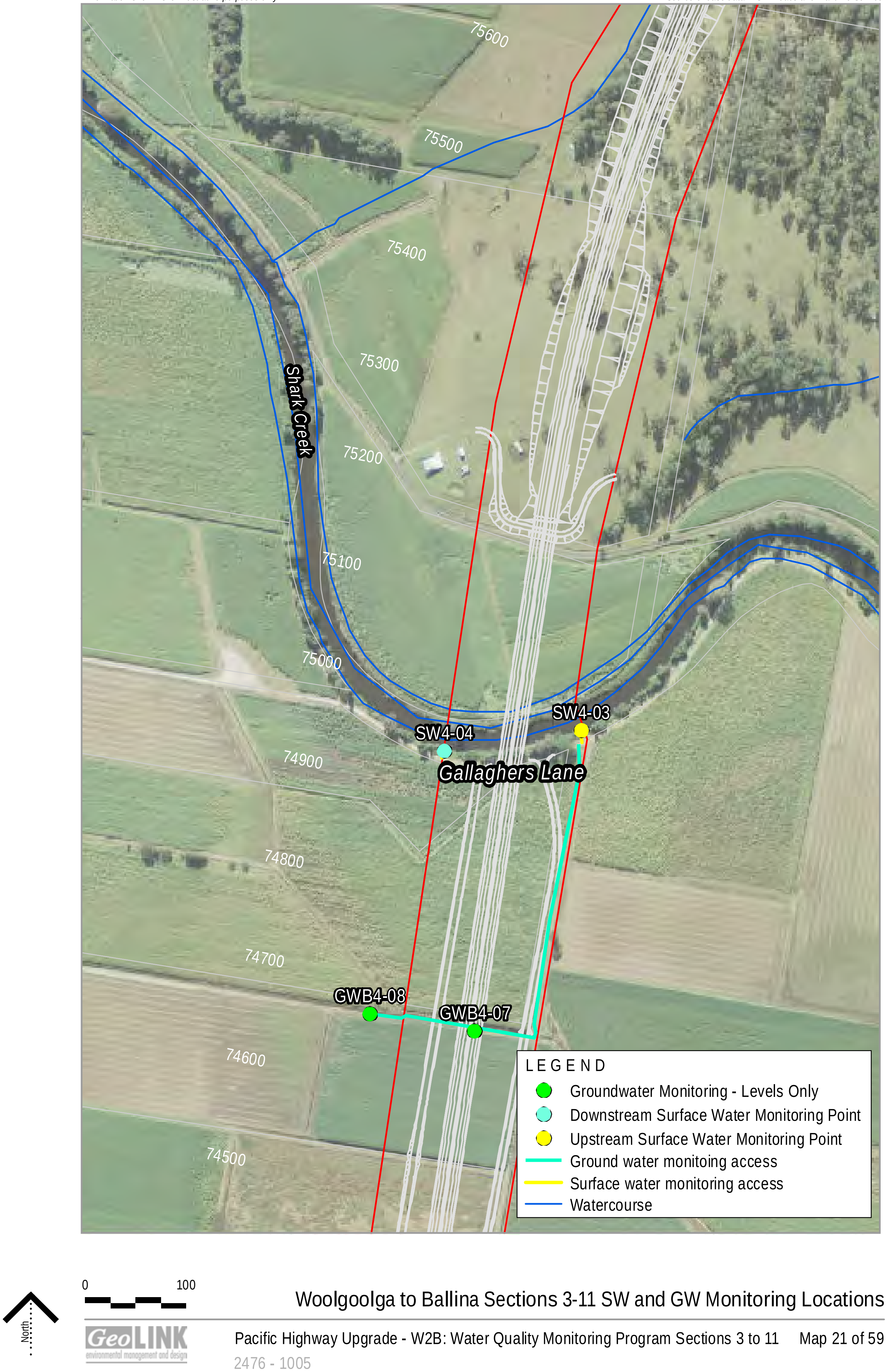

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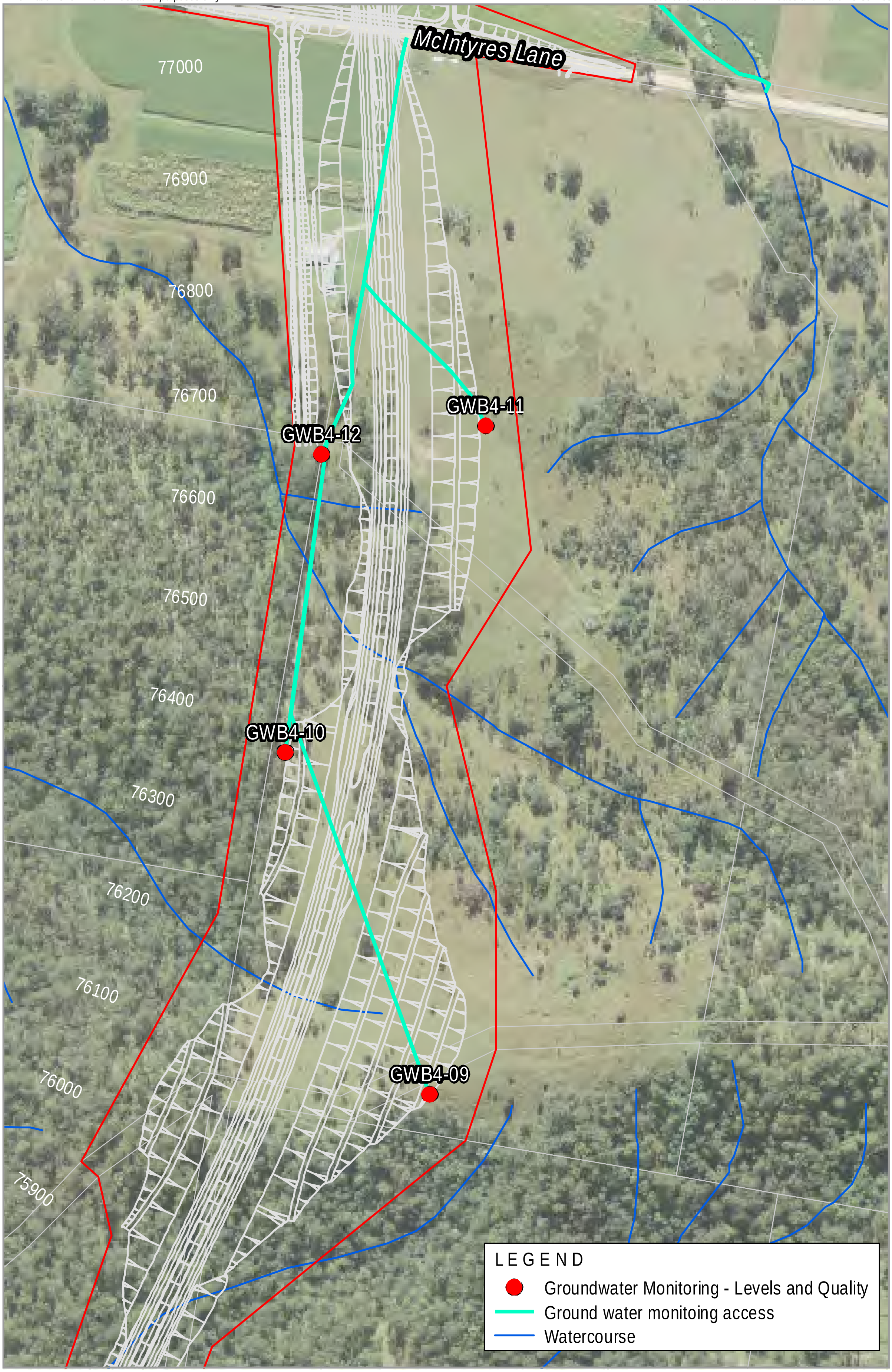

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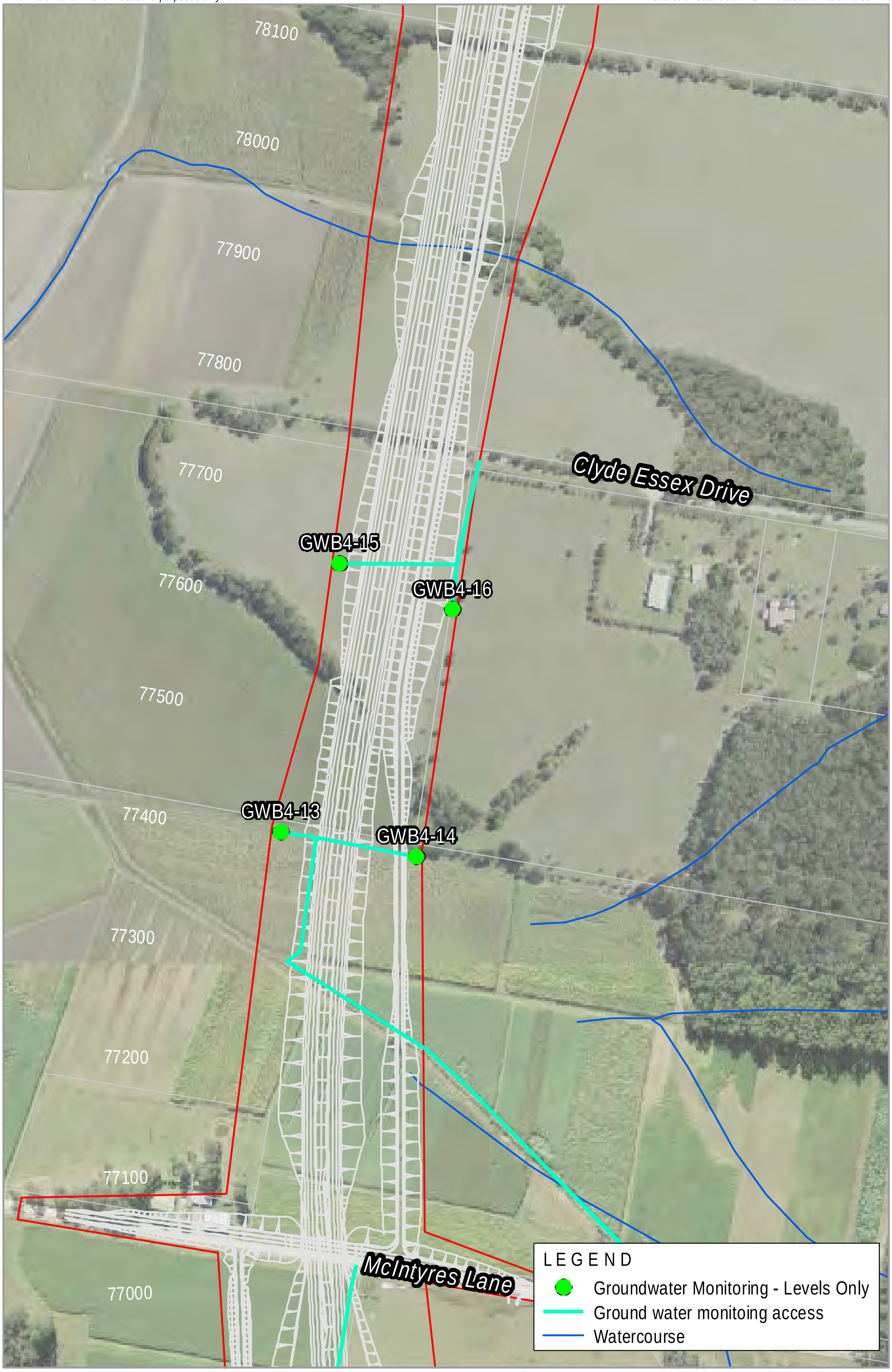

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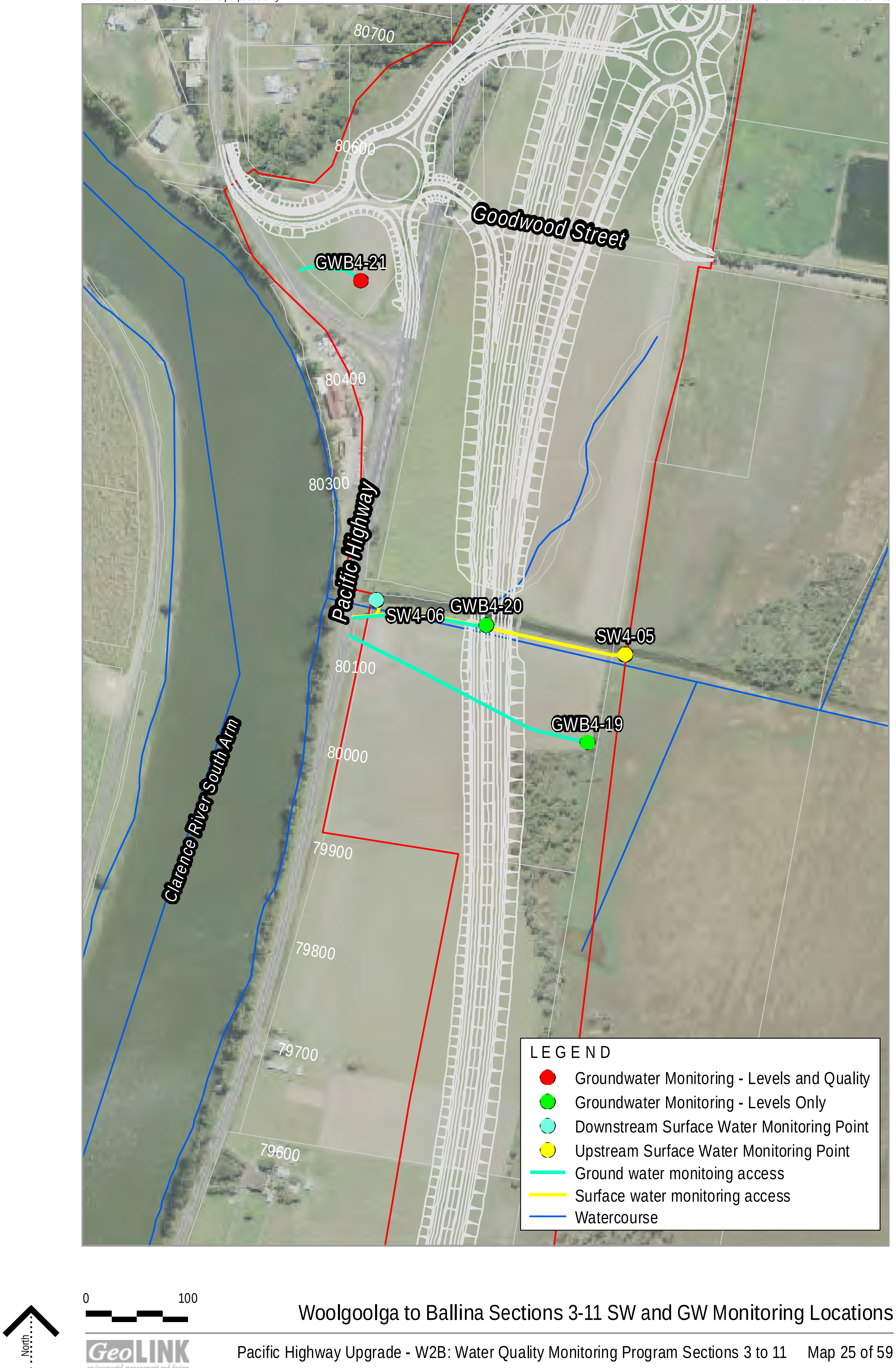

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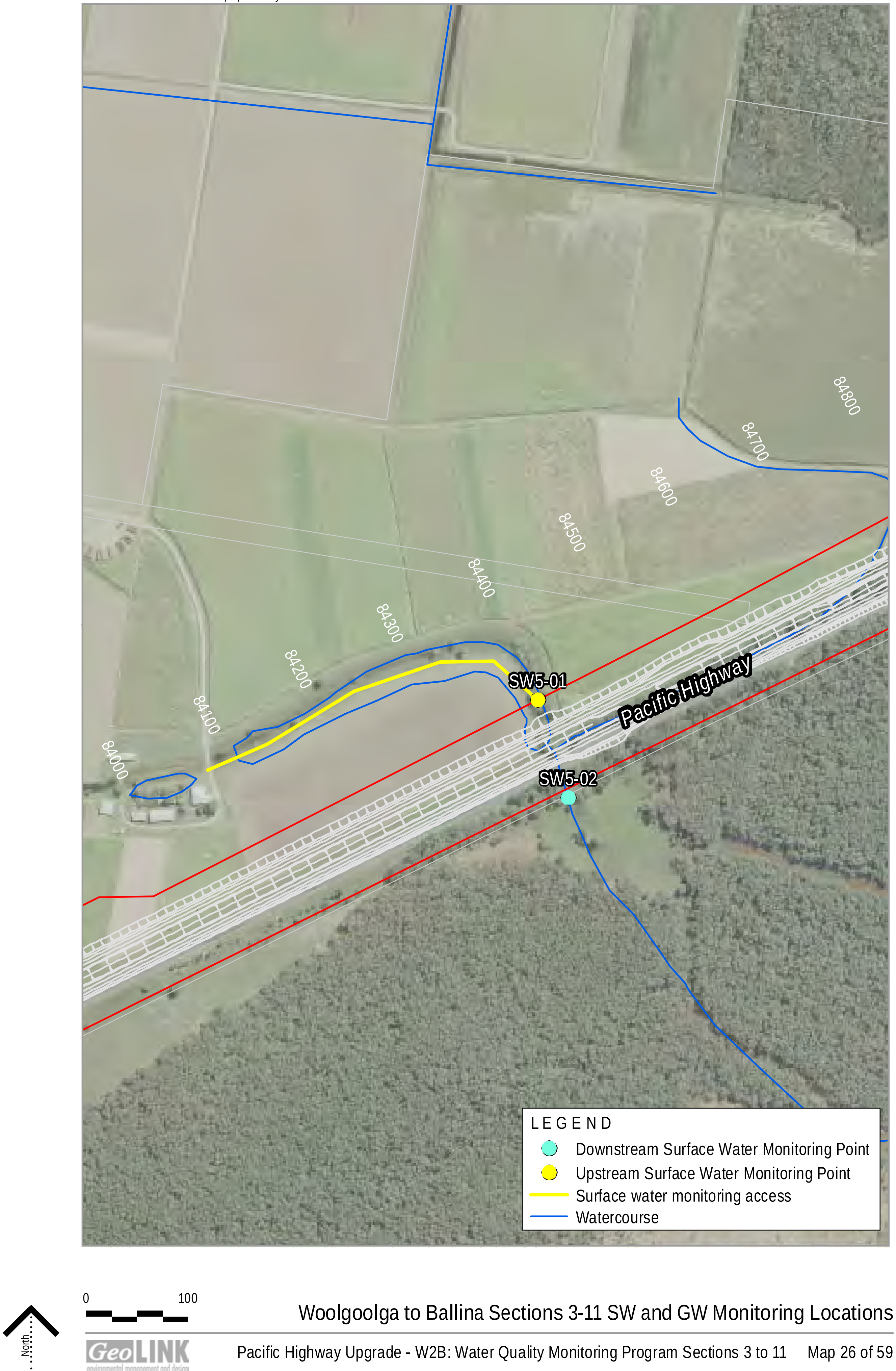

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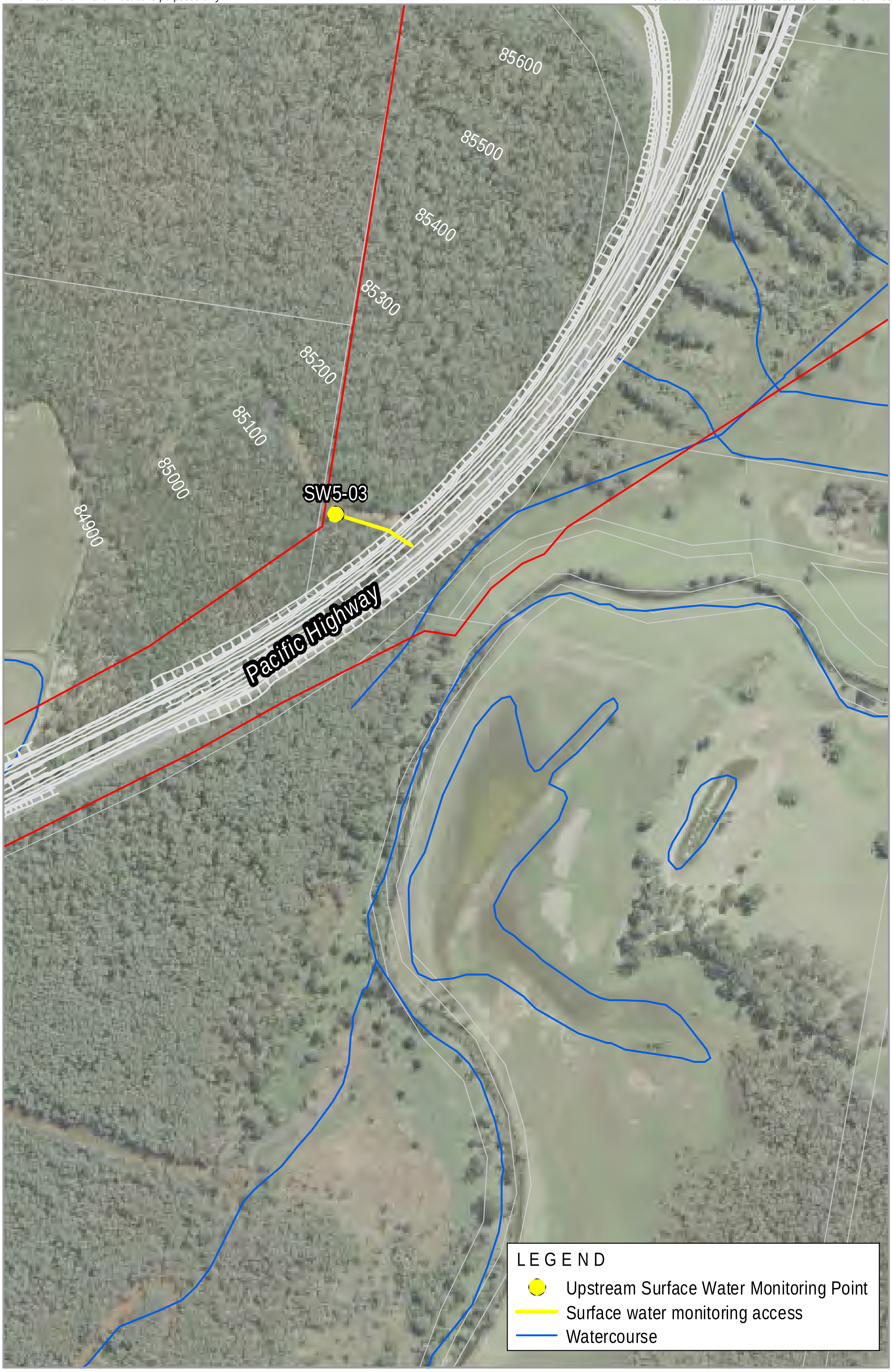

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Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

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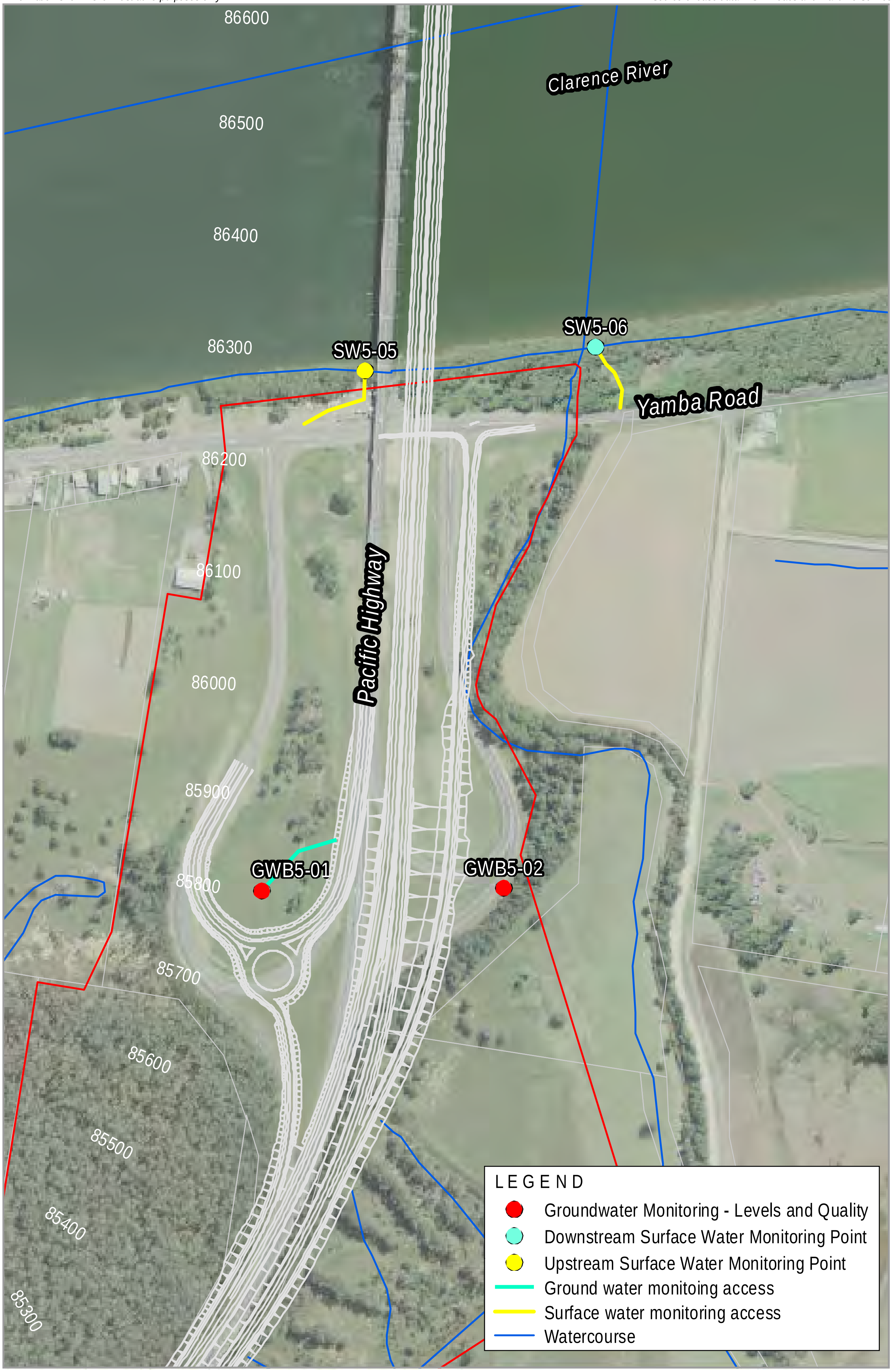

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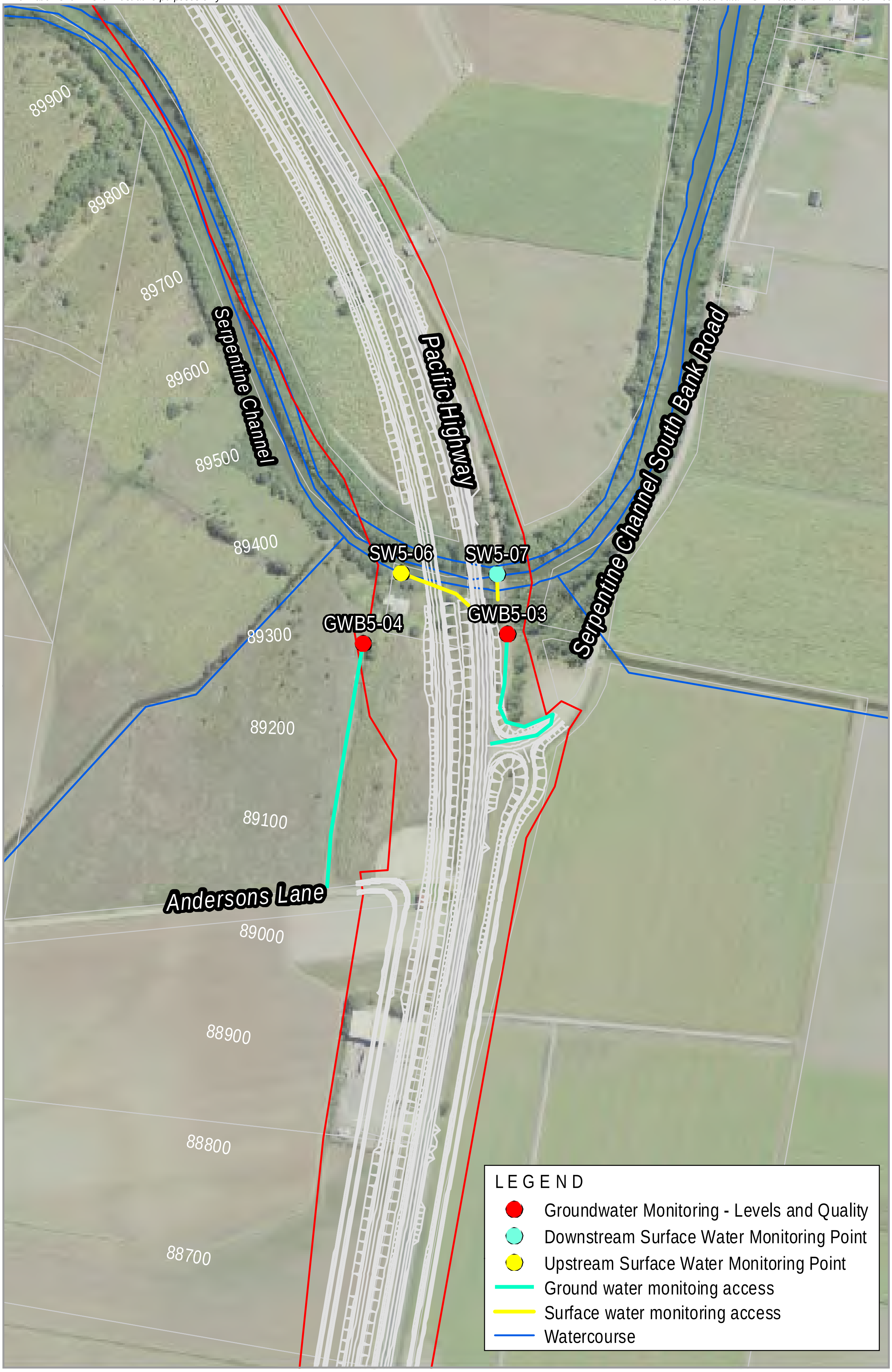

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Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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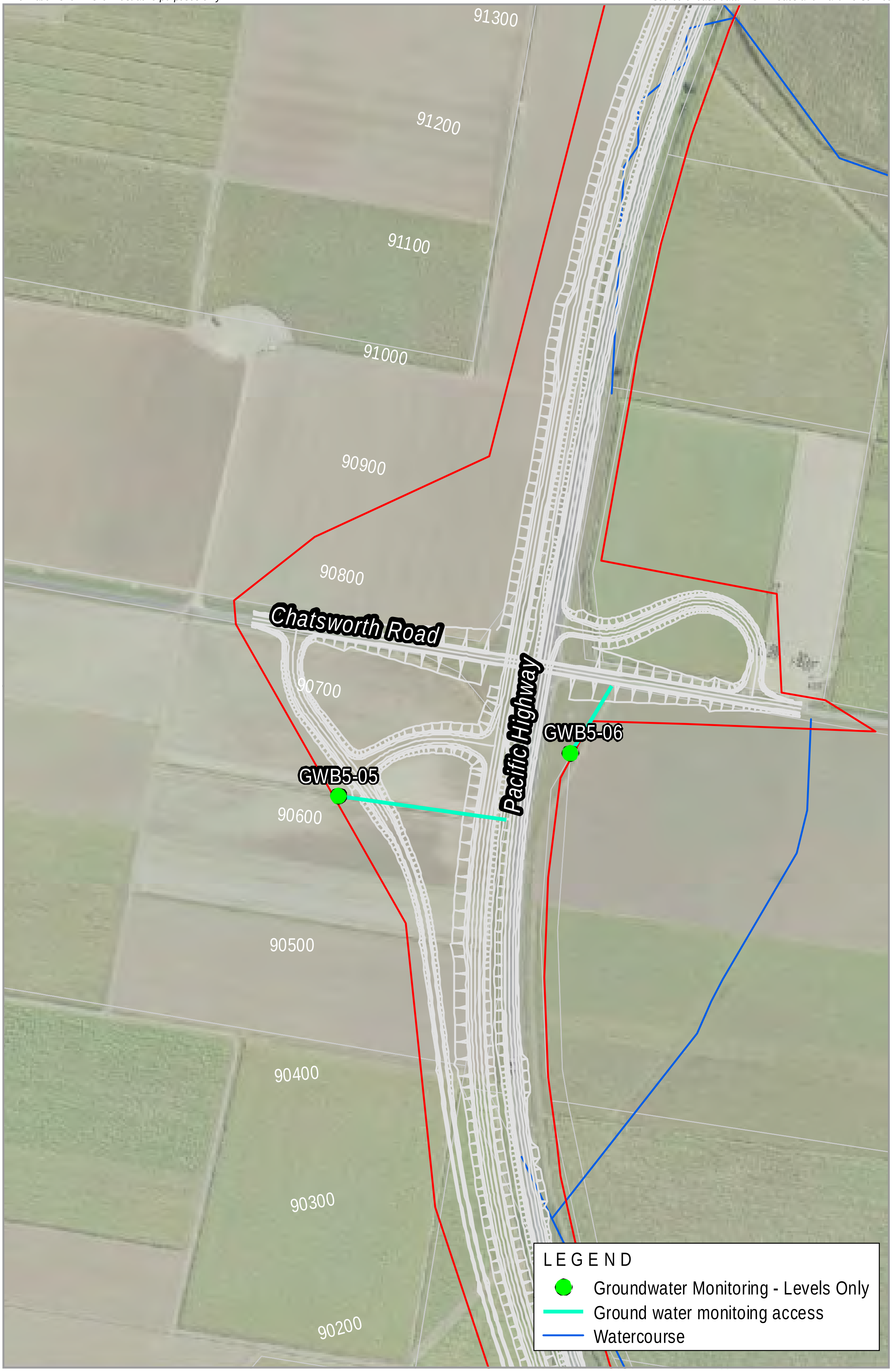

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Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

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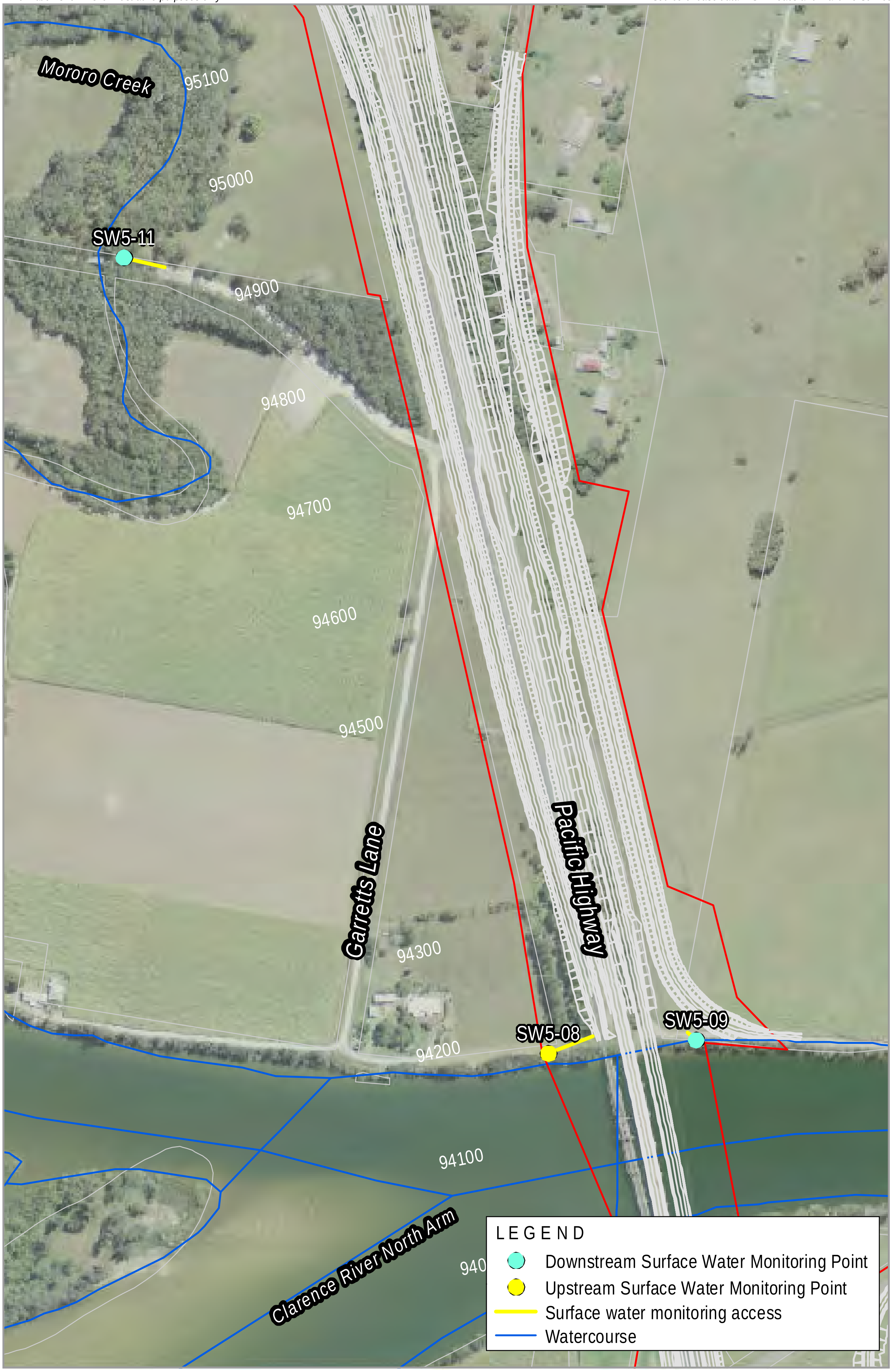

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Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

2476 - 1005

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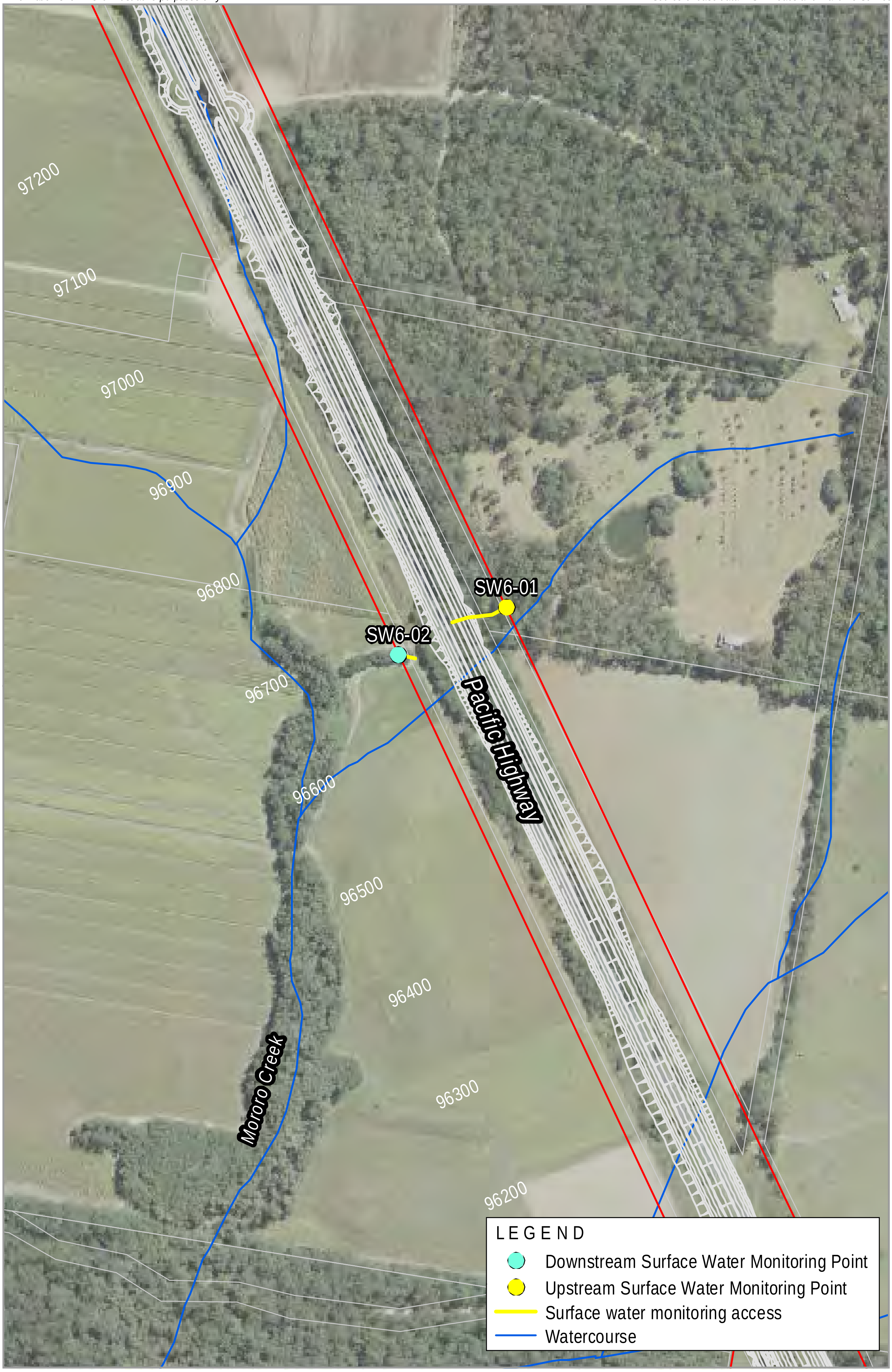
Source of base data: NSW Roads and Maritime Service
Information shown is for illustrative purposes only



Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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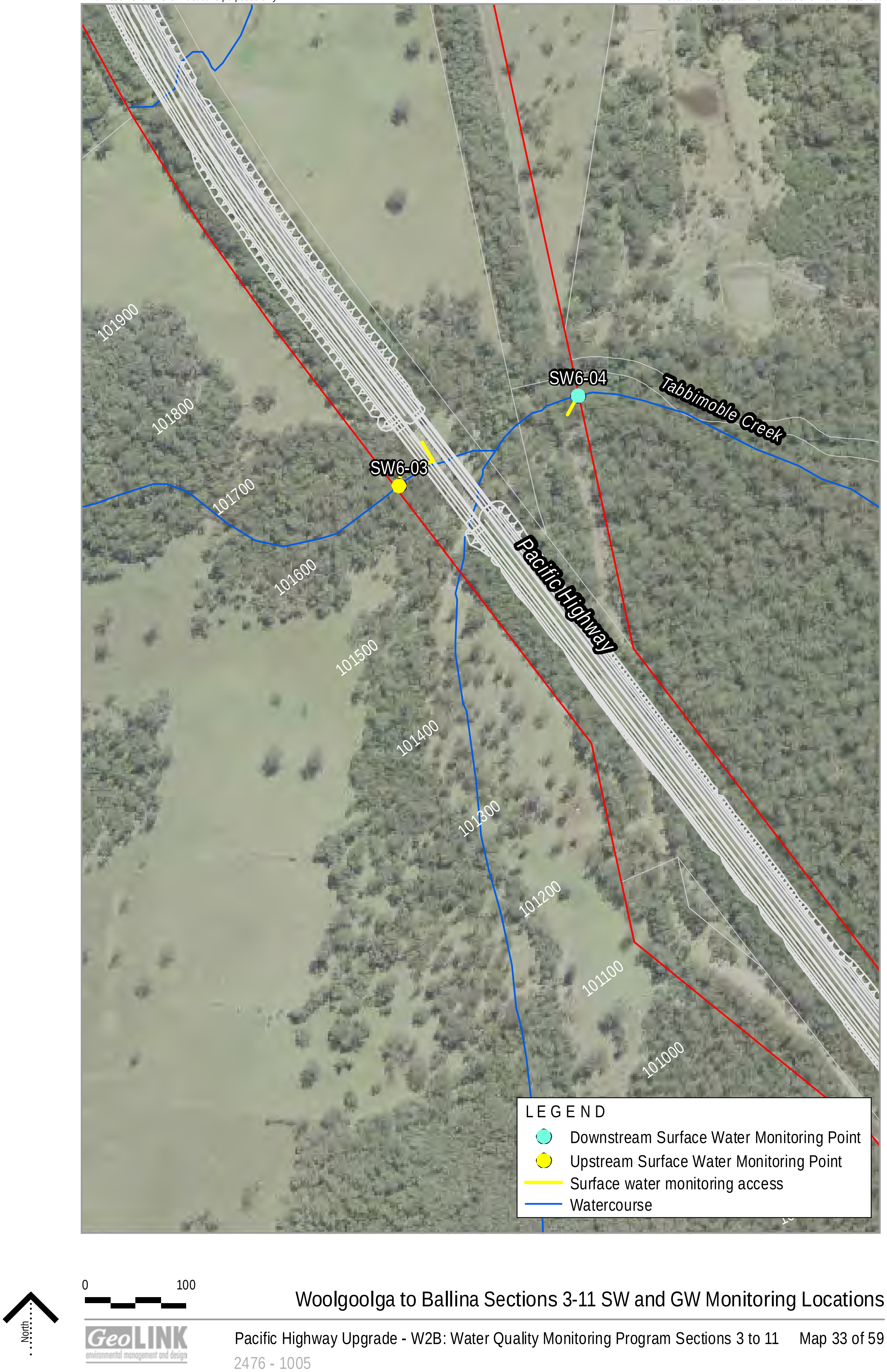
Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

2476 - 1005



Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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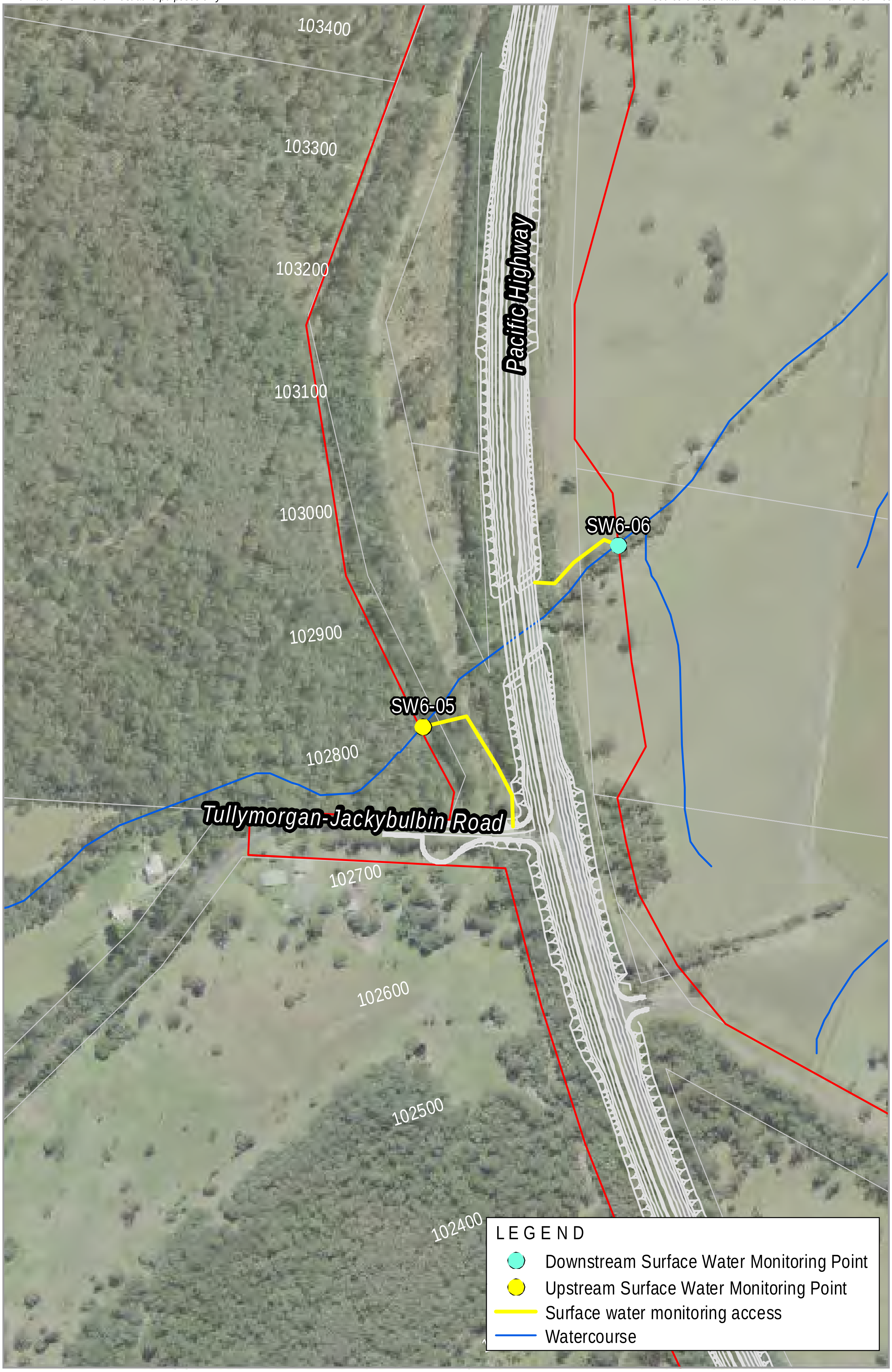
Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11 Map 33 of 59

2476 - 1005



Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

2476 - 1005

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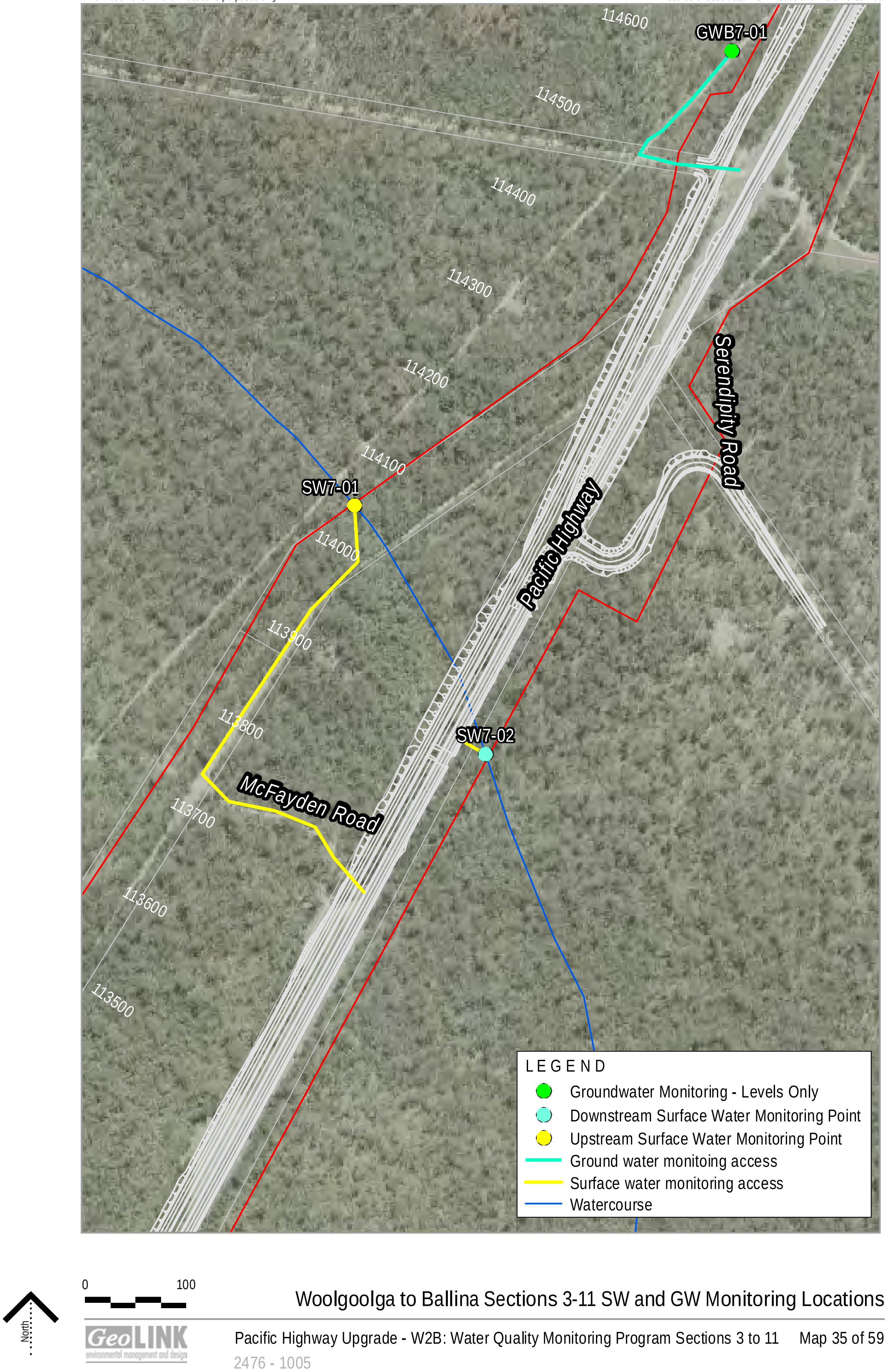
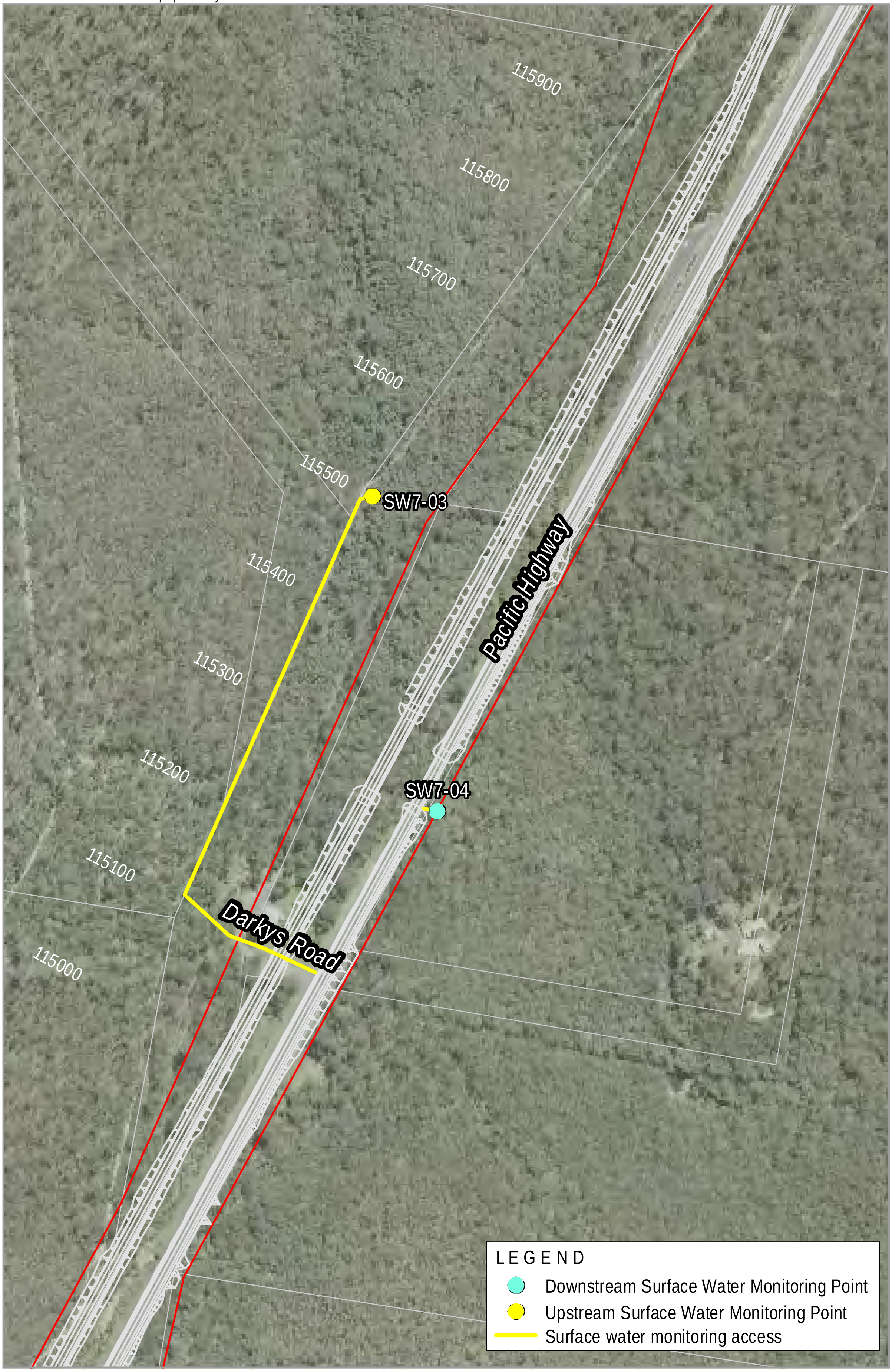


Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

2476 - 1005



Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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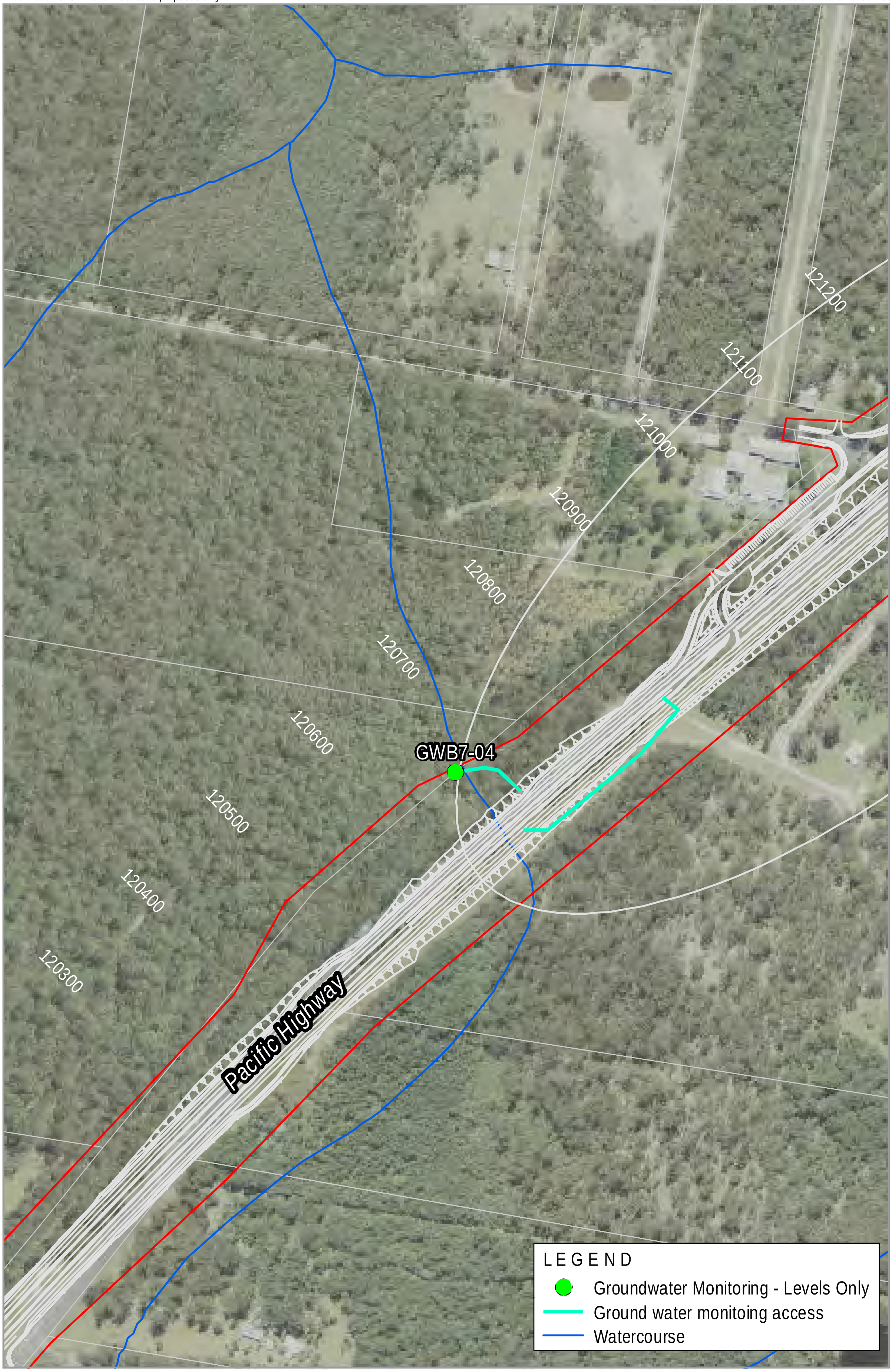

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Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11 Map 37 of 59

2476 - 1005

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Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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2476 - 1005

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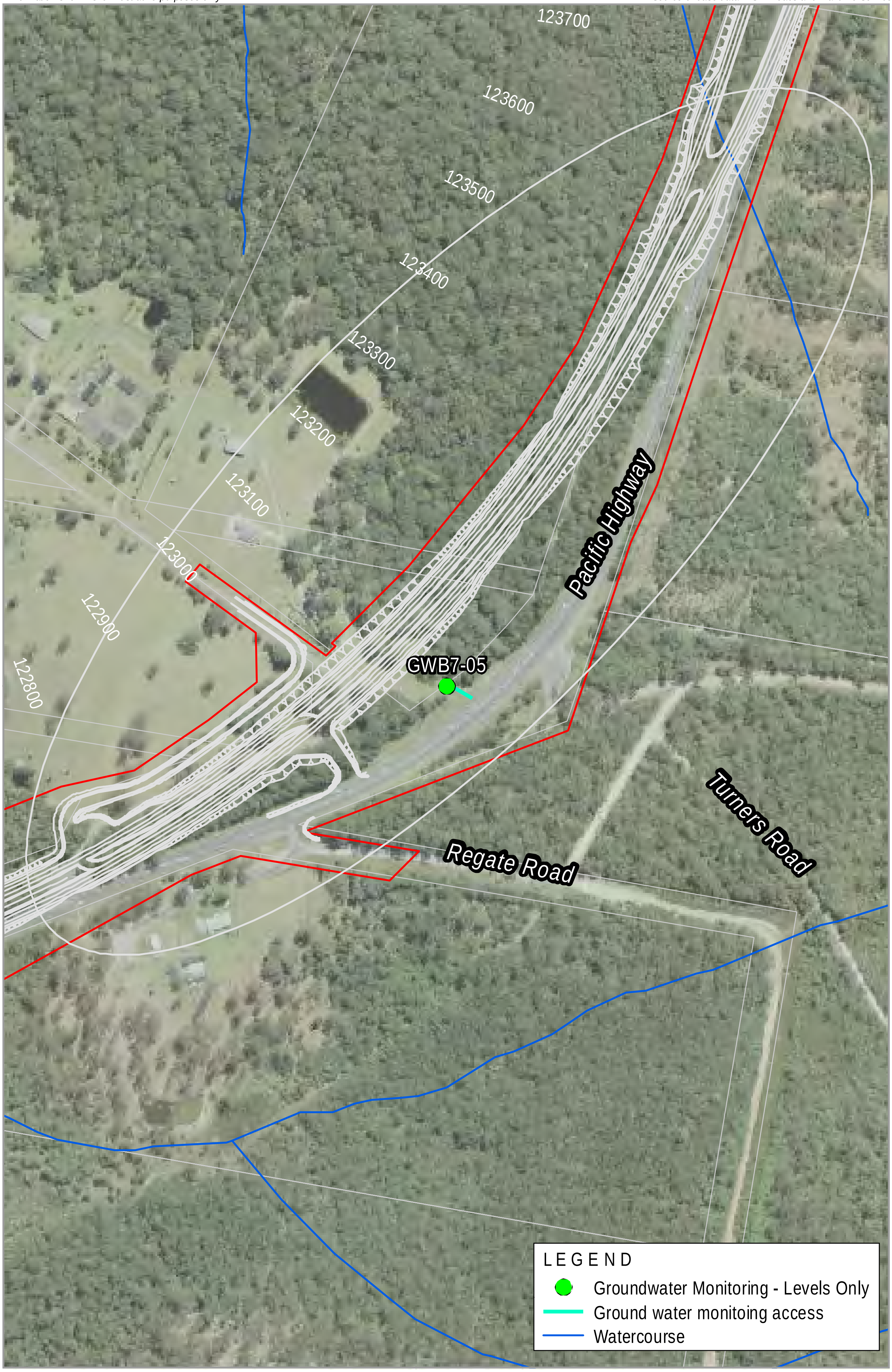

Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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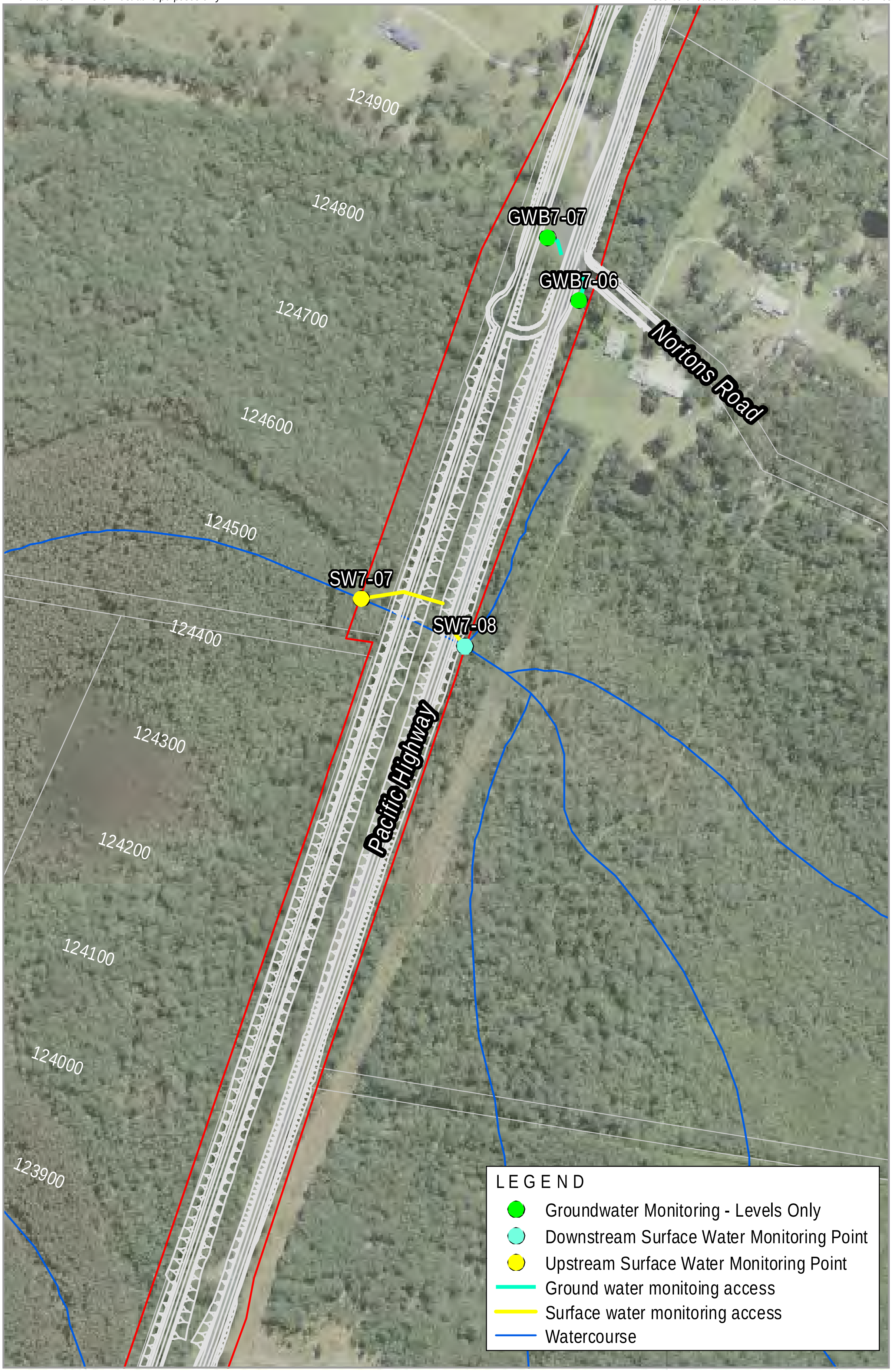
Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

2476 - 1005



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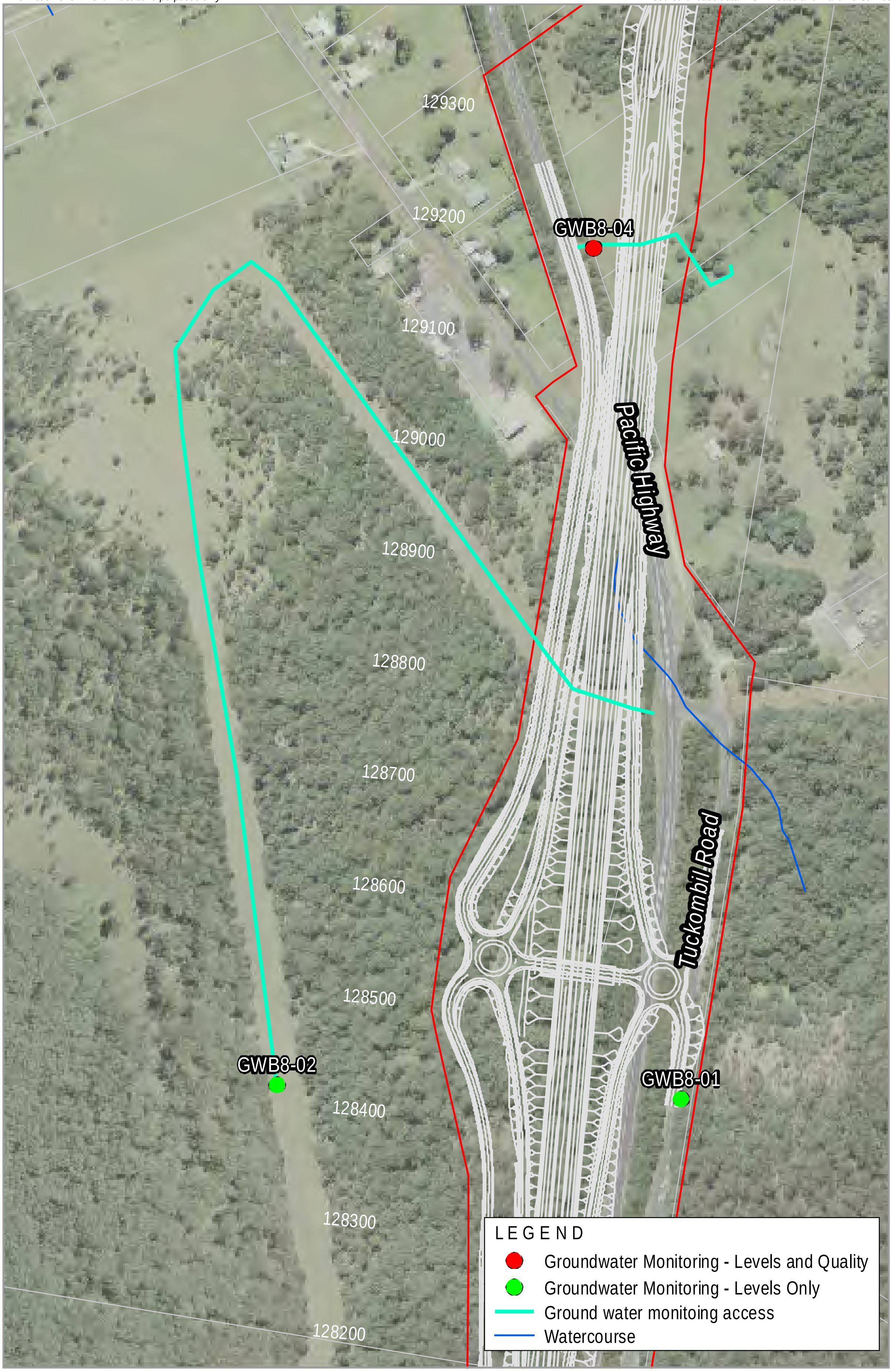
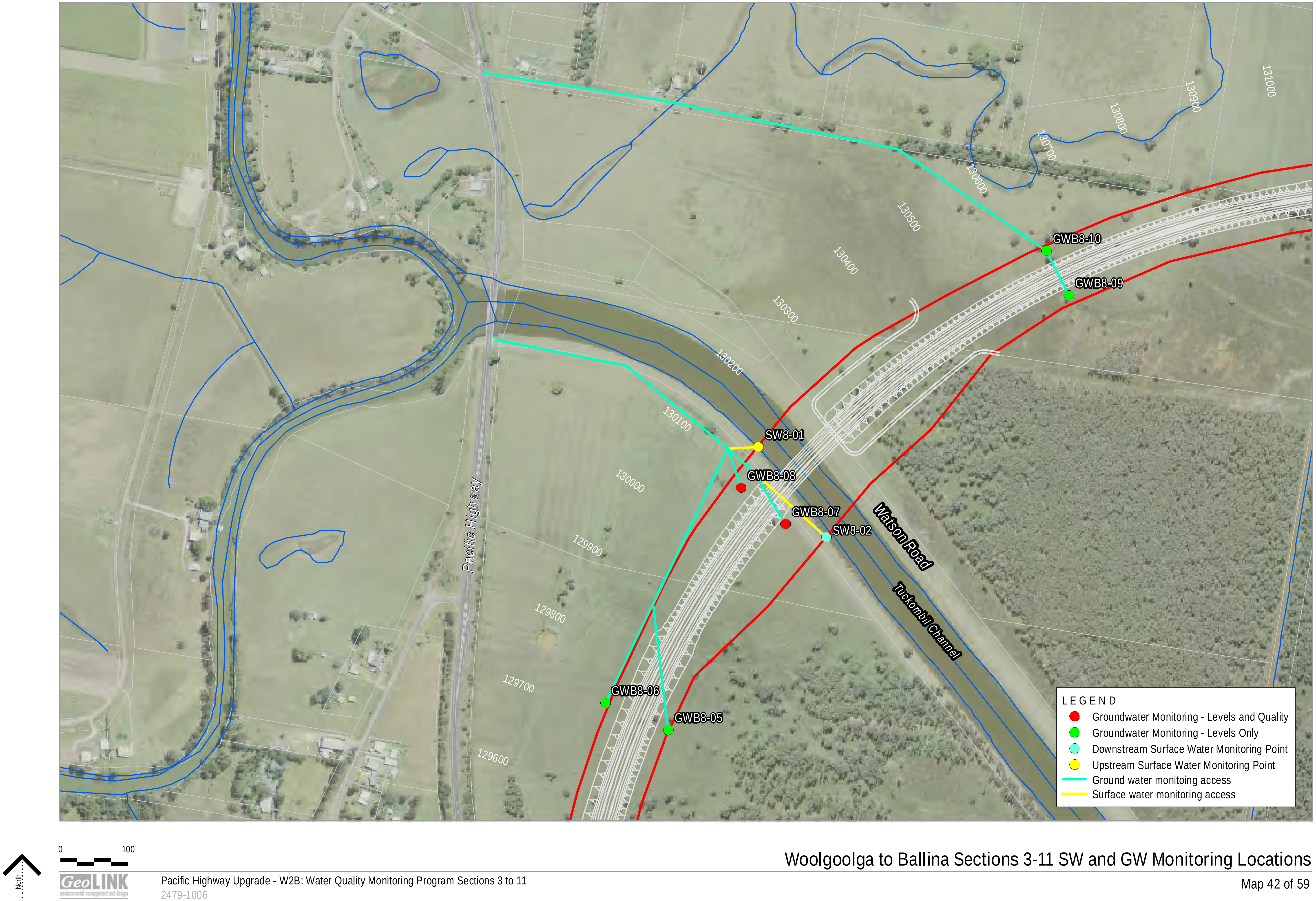


Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations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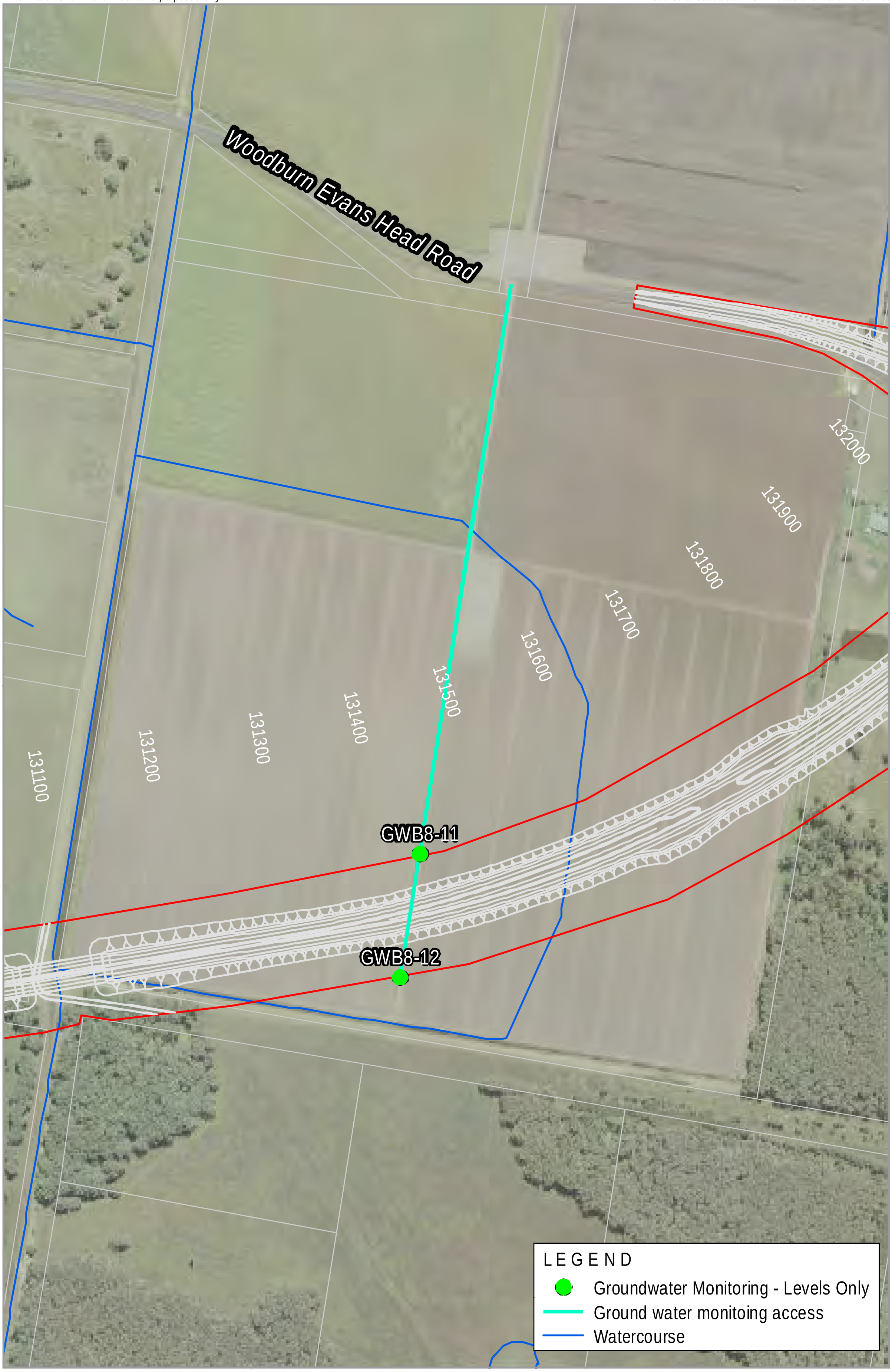
GWB8-09
SW8-01
GWB8-08
GWB8-07
SW8-02
GWB8-06
GWB8-05
Watson Road
Tuckombil Channel
Pacific Highway
131000
130900
130800
130700
130600
130500
130400
130300
130200
130100
130000
129900
129800
129700
129600
LEGEND
Groundwater Monitoring - Levels and Quality
Groundwater Monitoring - Levels Only
Downstream Surface Water Monitoring Point
Upstream Surface Water Monitoring Point
Ground water monitoing access
Surface water monitoring access
0
100
North



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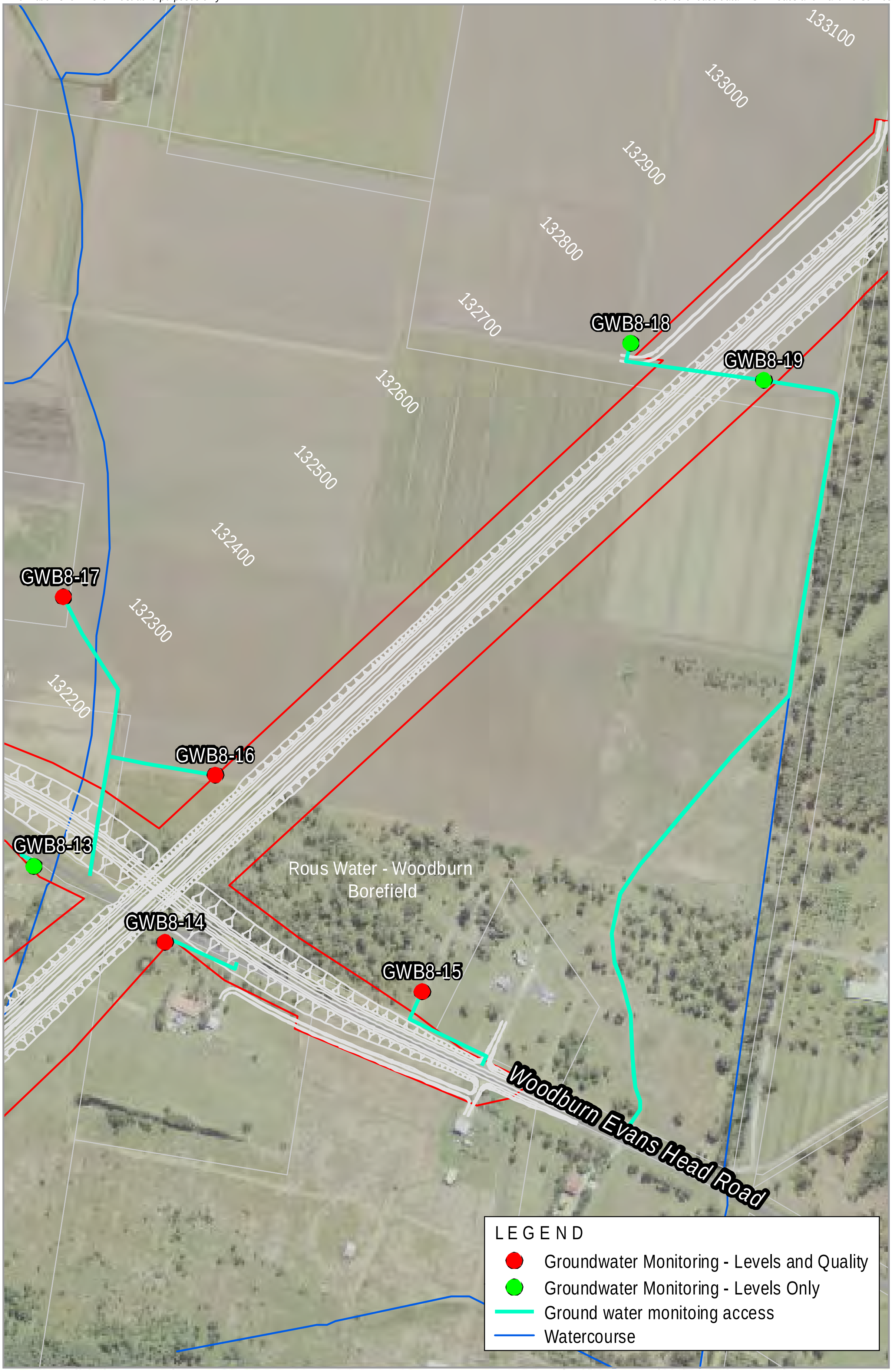
Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations



Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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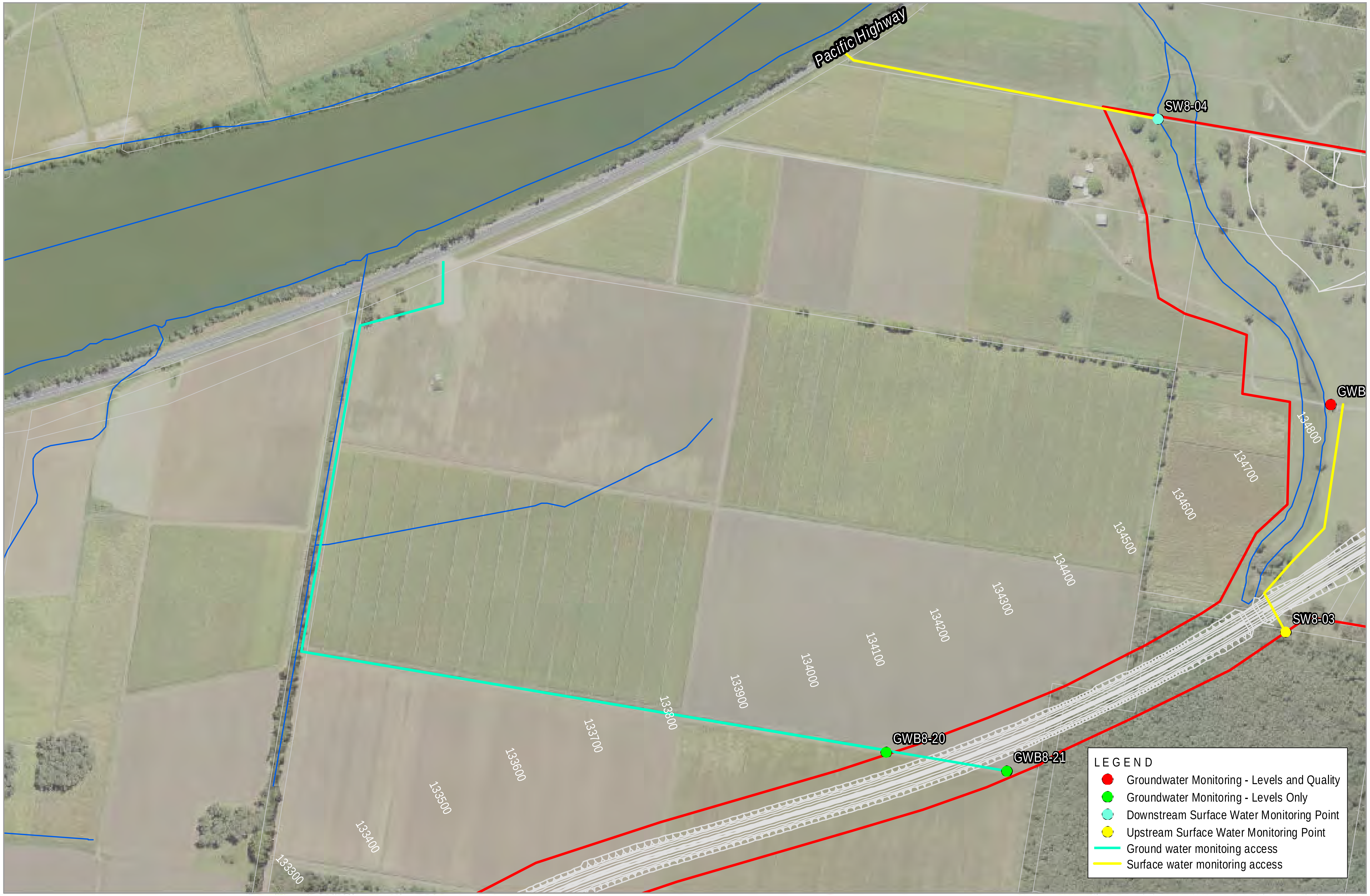

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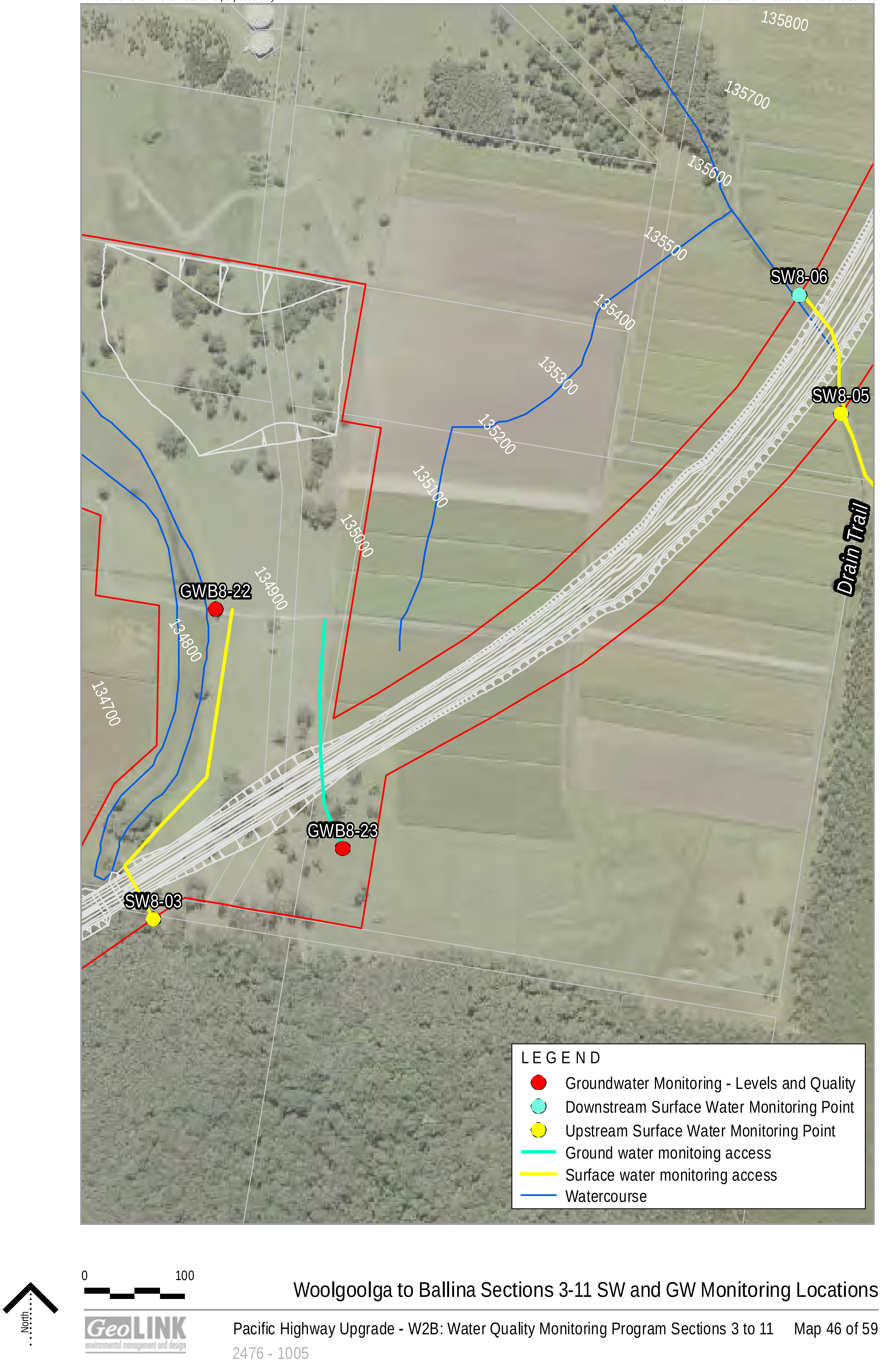
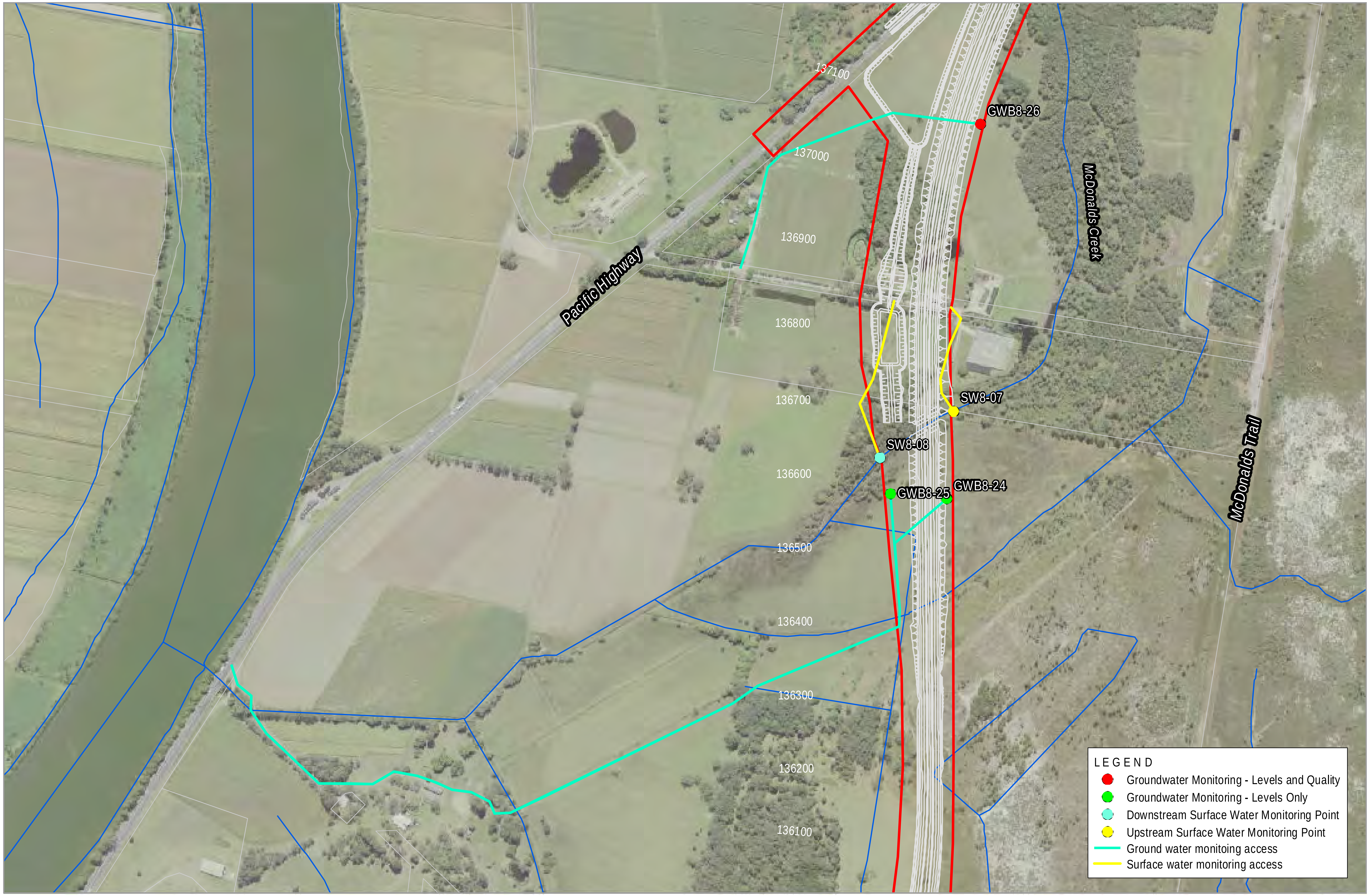
Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11
2479-1006

Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

Information shown is for illustrative purposes only



Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations



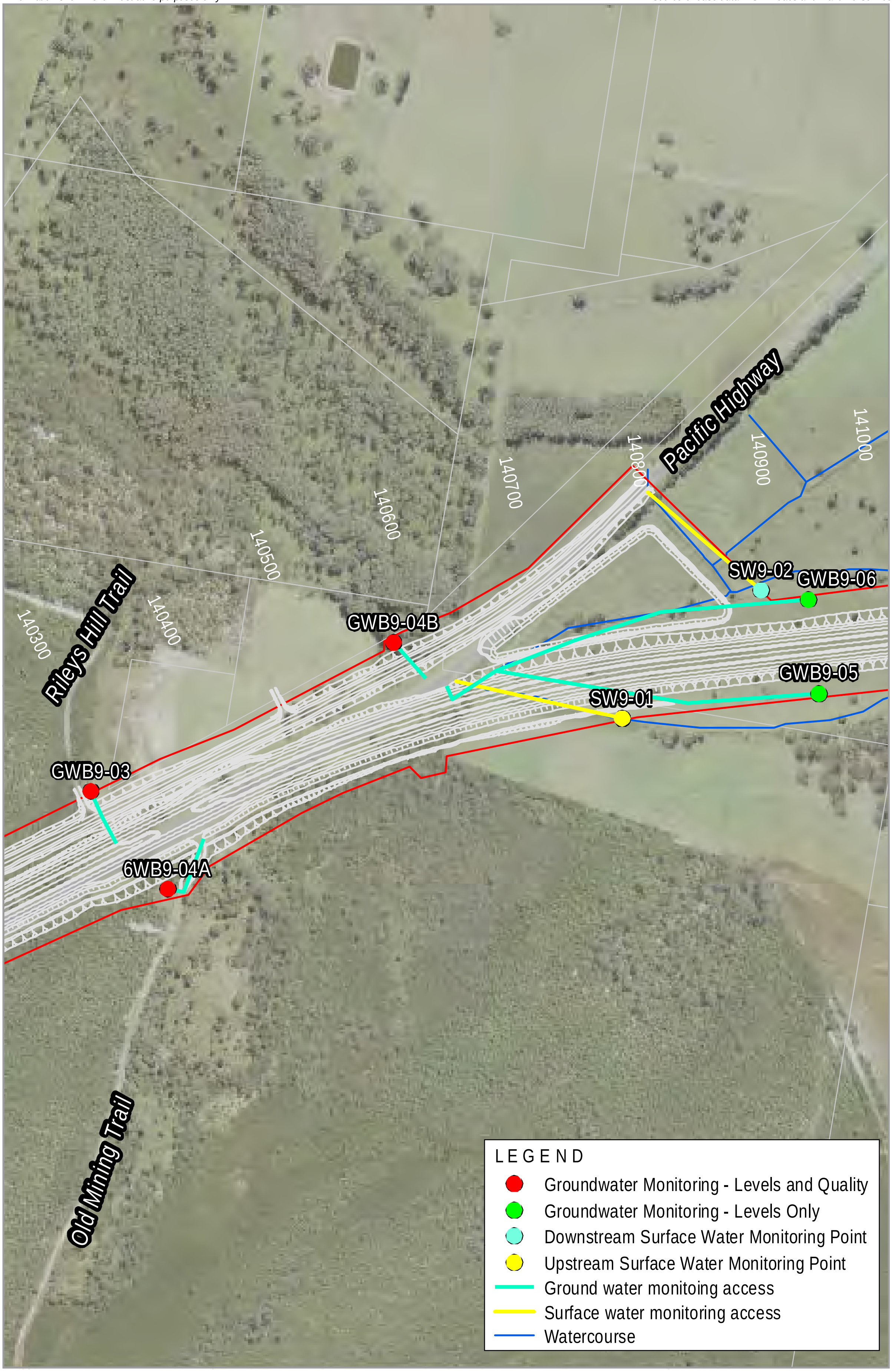
Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

GeoLINK environmental management and design

Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

2479-1006

Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations



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Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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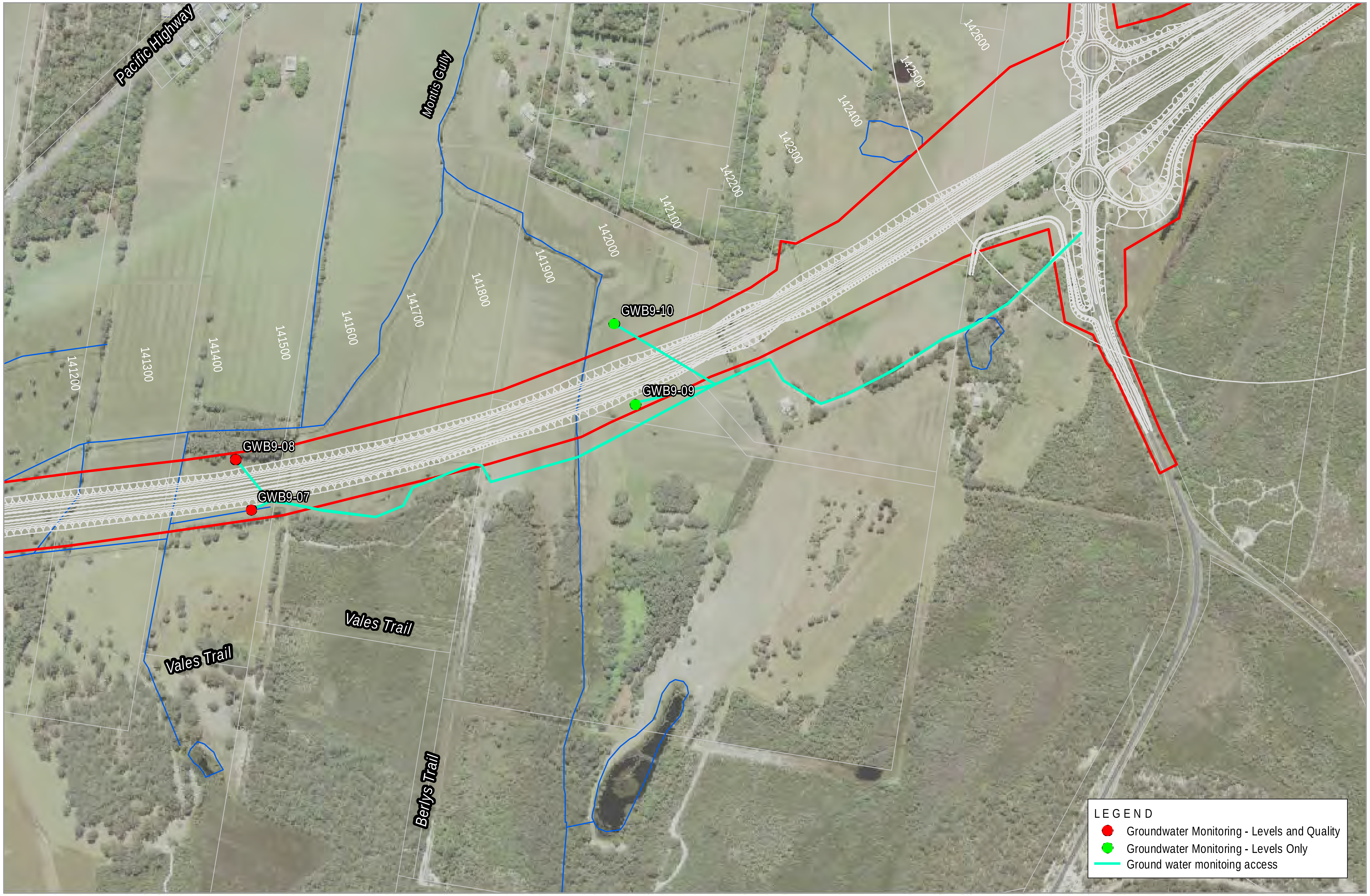

Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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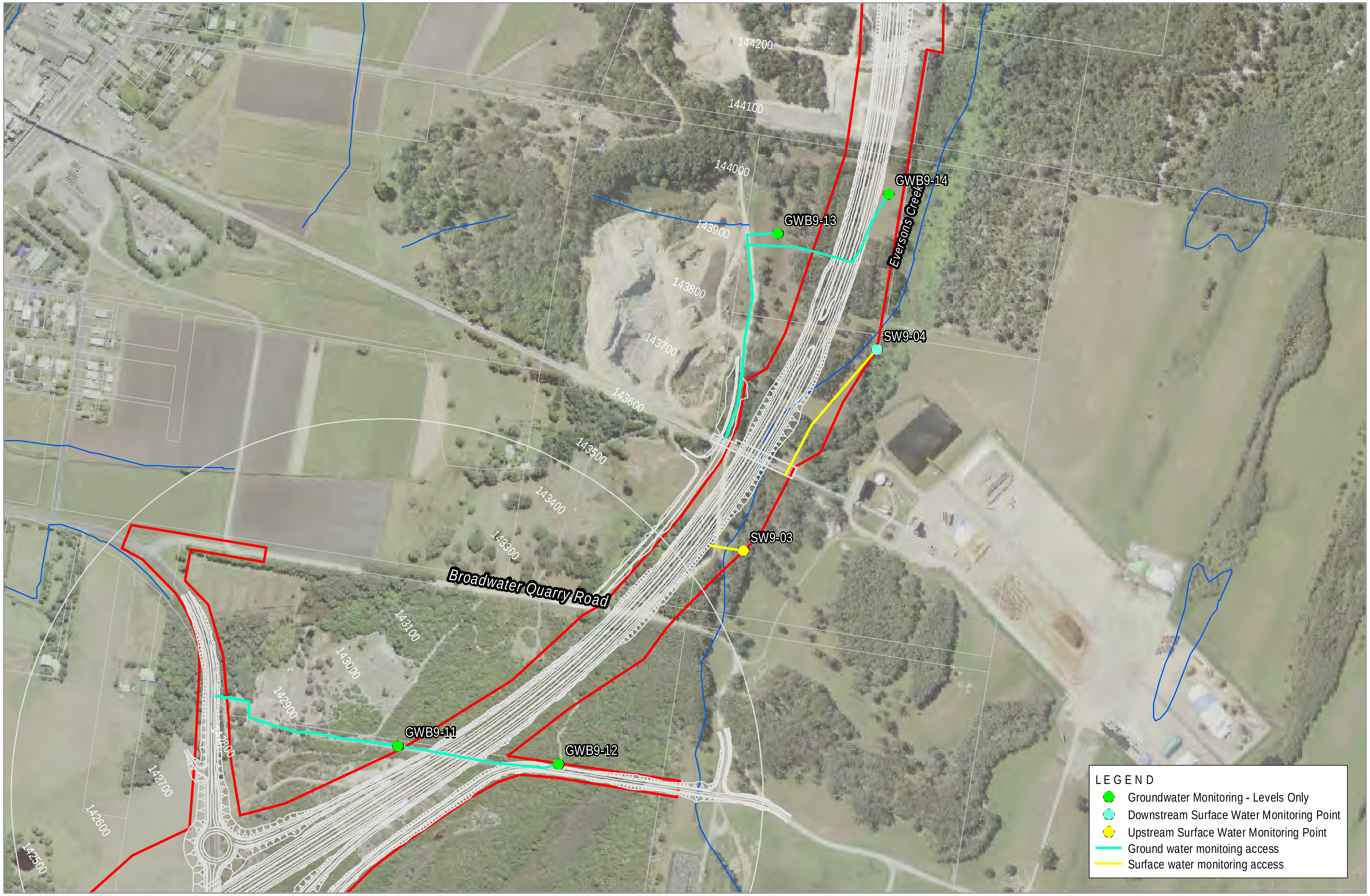
Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

2479-1006



Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11
2479-1006

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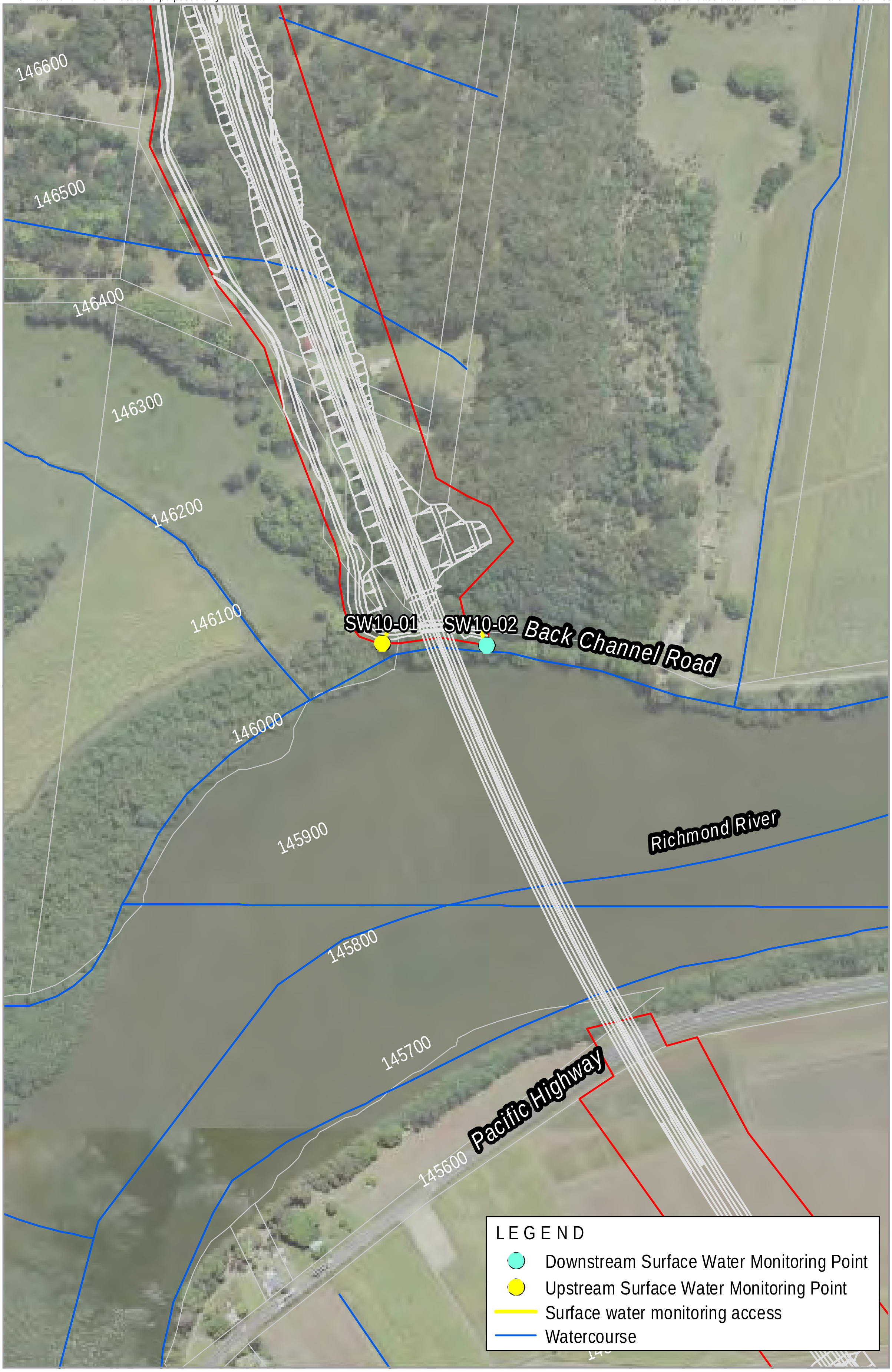

Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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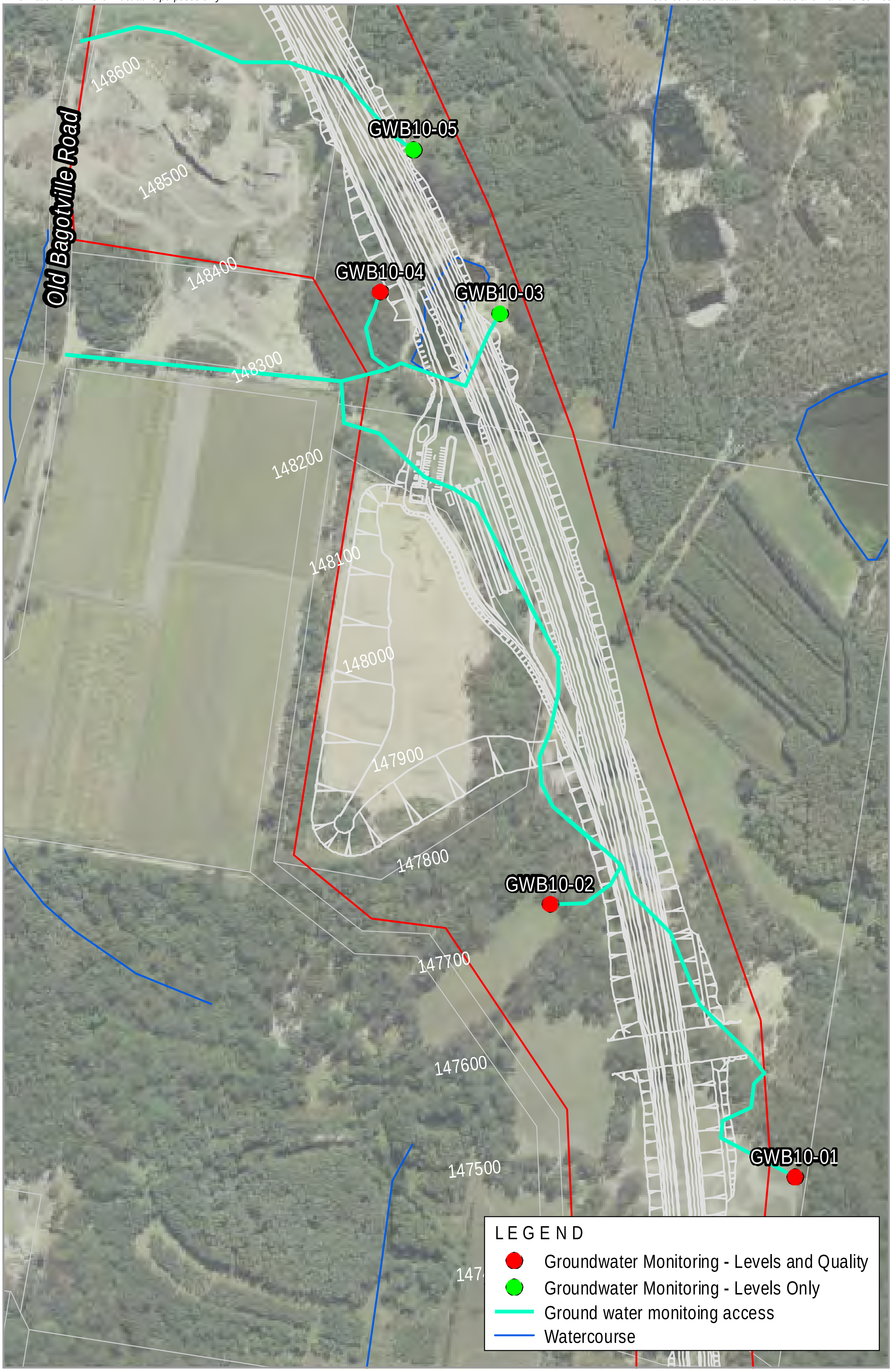

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North

Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11 Map 53 of 59

2476 - 1005

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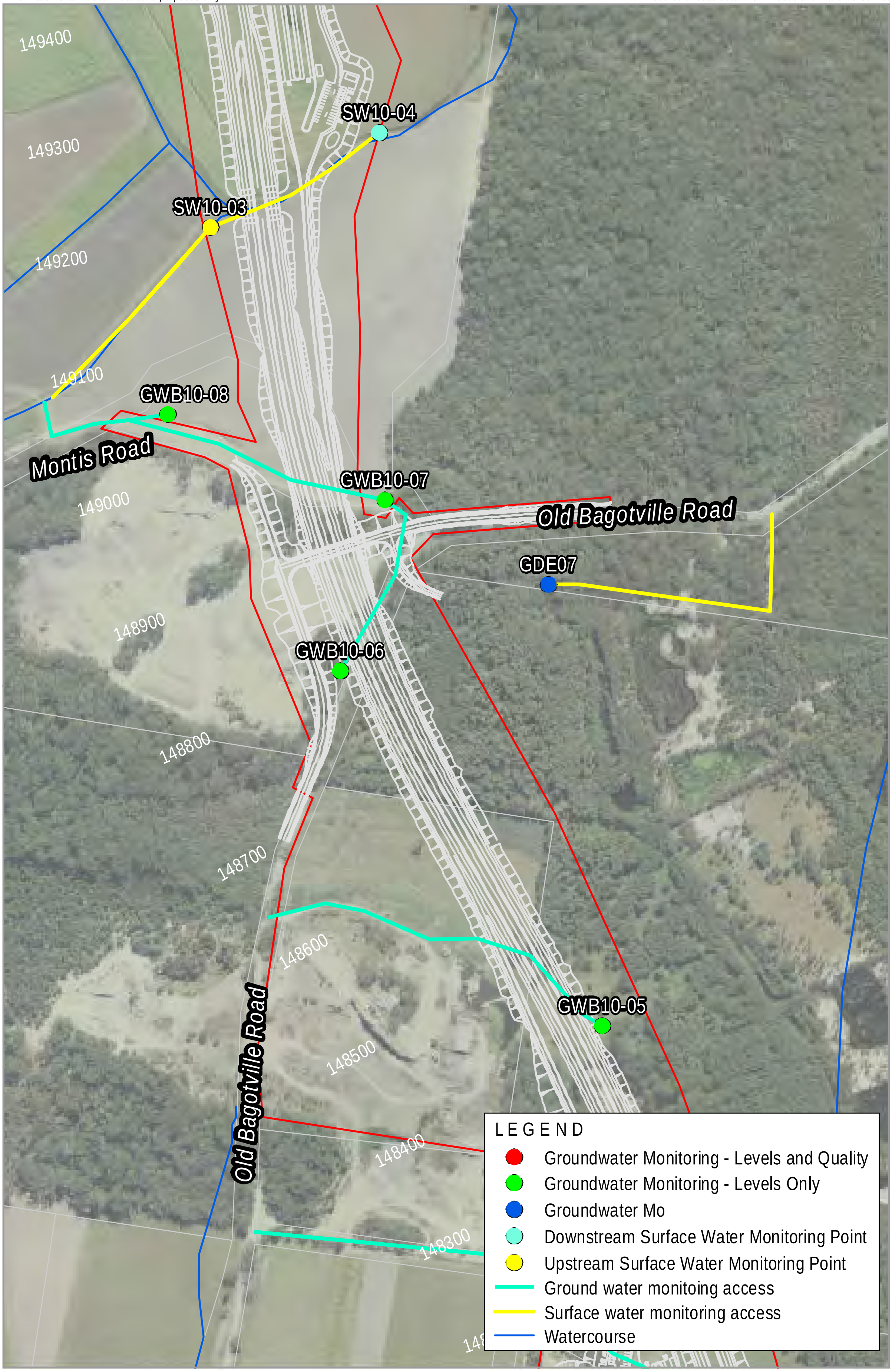

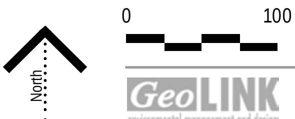

Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

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Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11 Map 54 of 59

2476 - 1005

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Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

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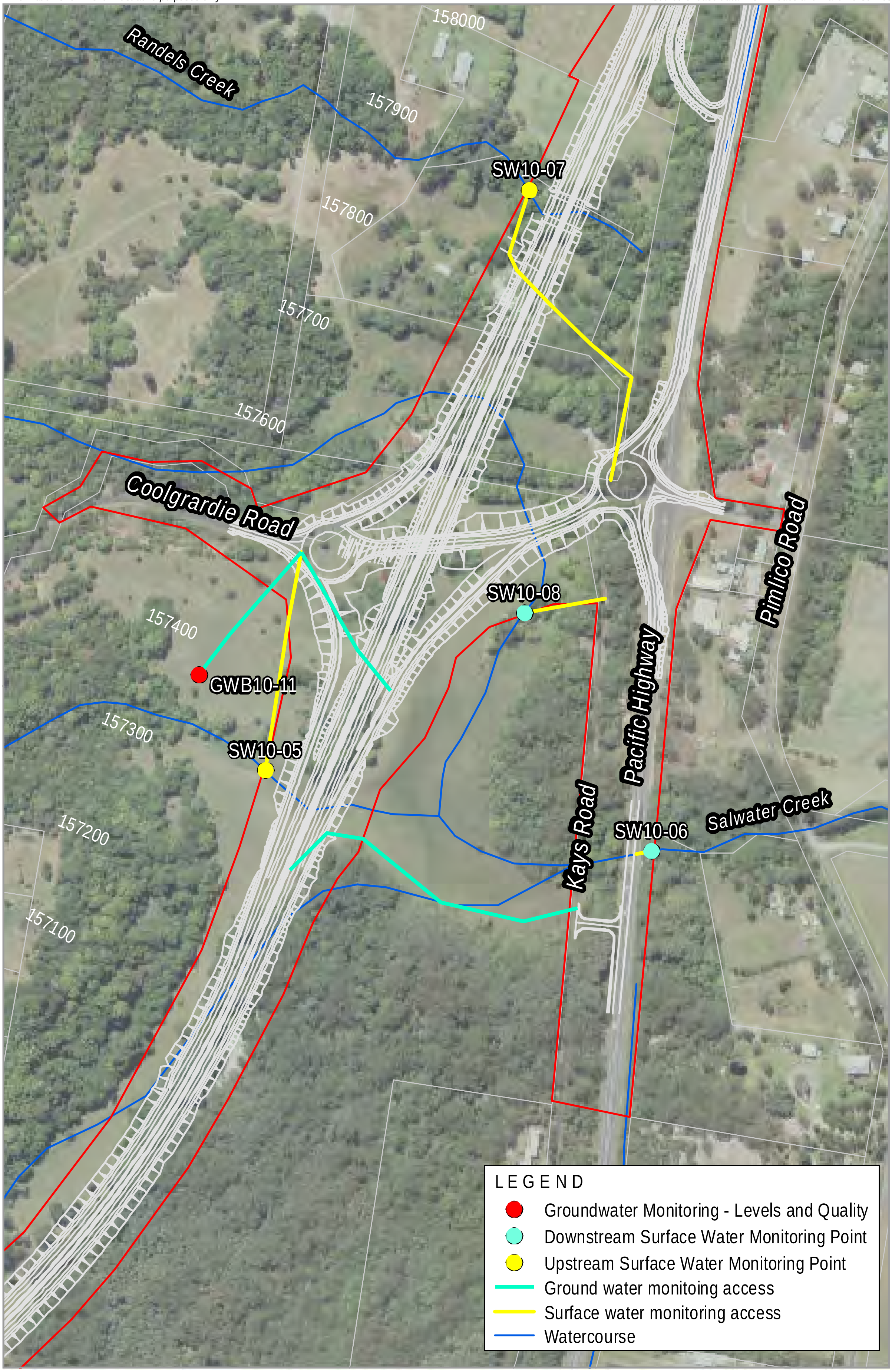

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Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

Pacific Highway Upgrade - W2B: Water Quality Monitoring Program Sections 3 to 11

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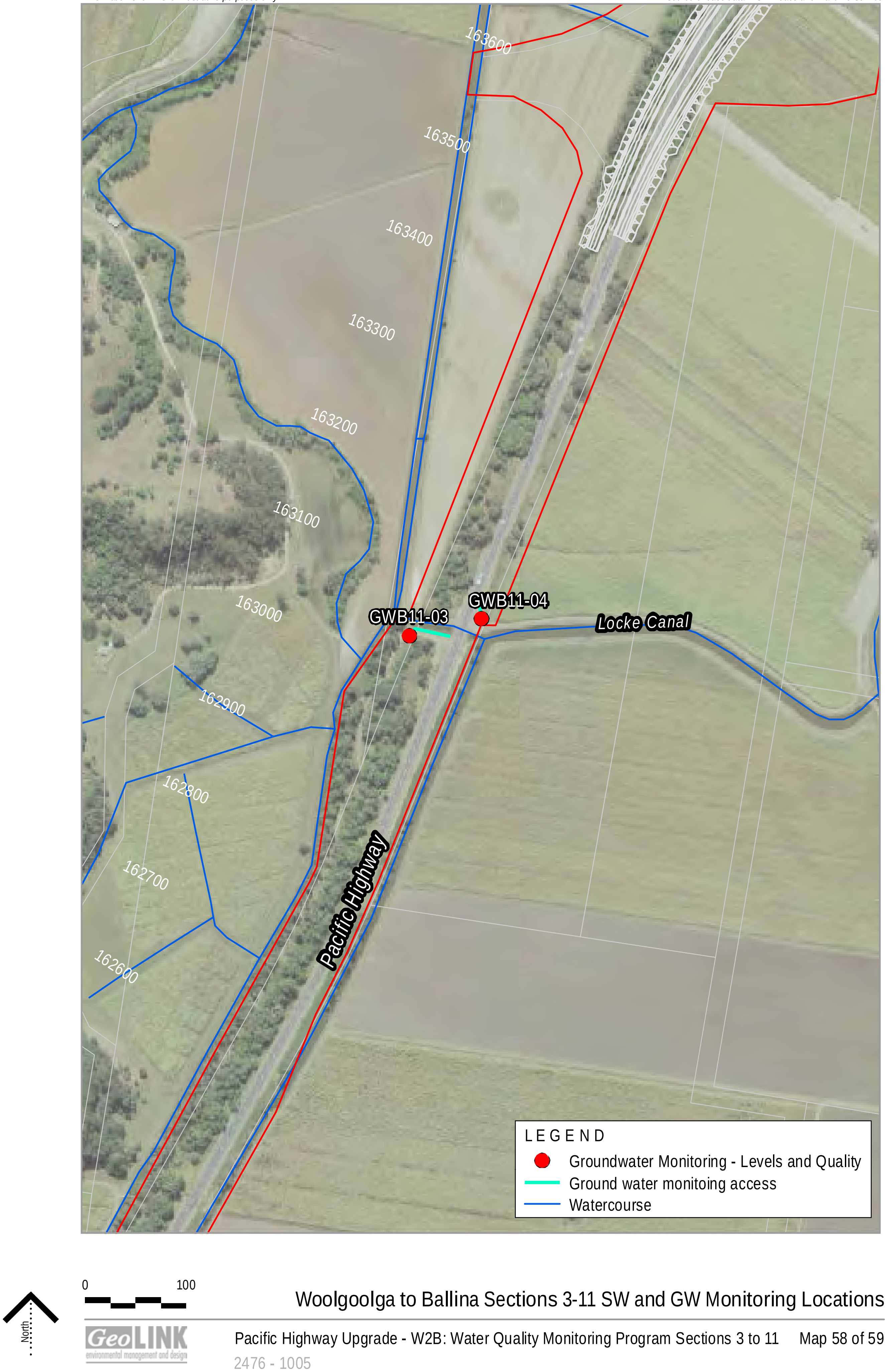
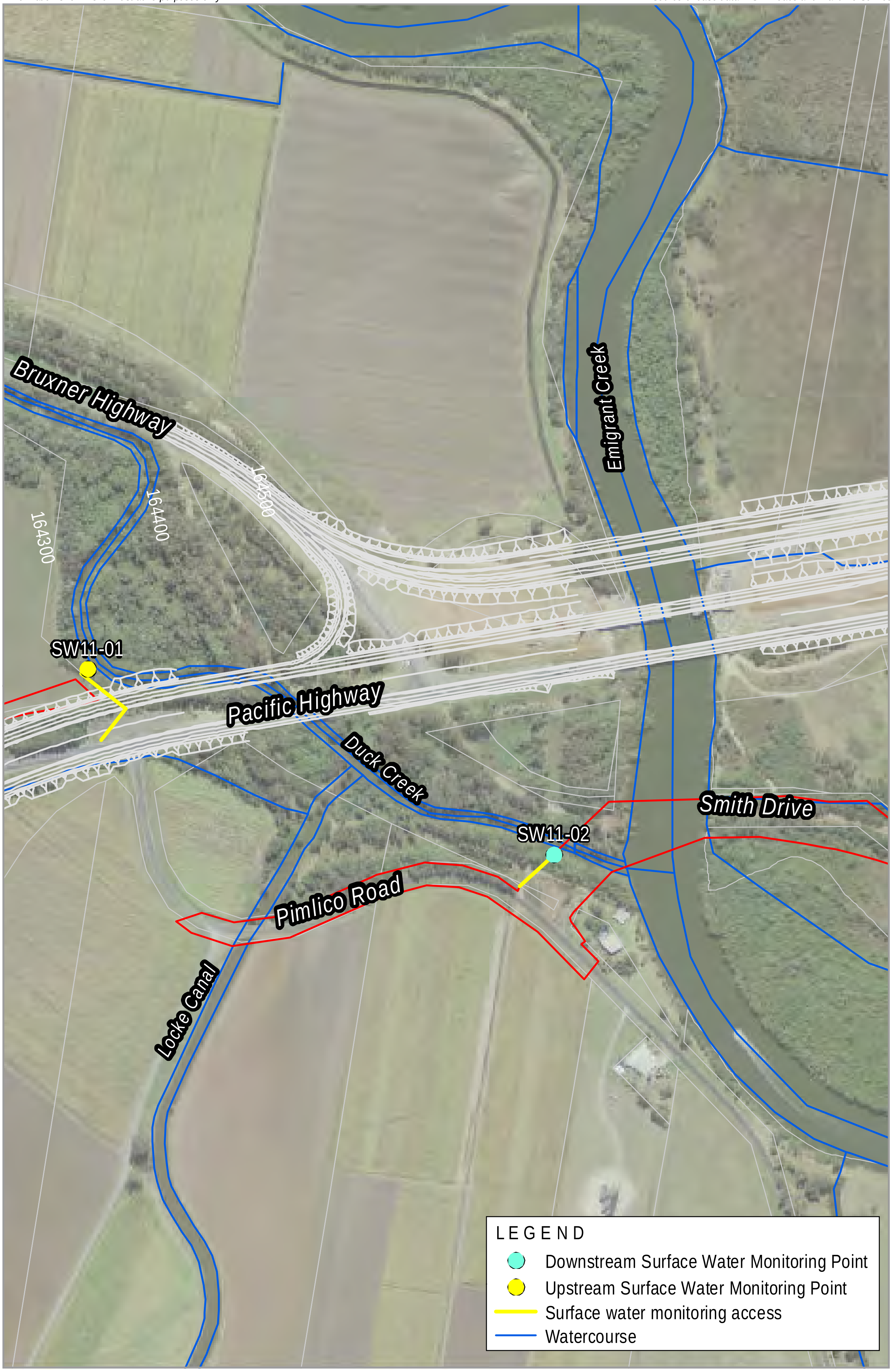
Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations



Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations



Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations

Appendix B

Section 3 - Glenugie to Tyndale: Pre-Construction Monitoring Results

Section 3: Surface Water Monitoring Locations and associated Sensitive Receiving Environments

Surface Water Sample Locations / Waterway	*Waterway Description*	*Sensitive aquatic receiving environments and groundwater dependent ecosystems*
SW01 – Picanny Creek SW02 – Pheasant Creek SW03 – Unnamed tributary Glenugie Creek SW04 & SW05 – Coldstream River SW06 – Pillar Valley Creek SW07 – Black Snake Creek SW22 – Unnamed Creek tributary of Ellis Swamp SW08 – Chaffin Creek SW09 – Unnamed tributary of Chaffin Creek SW10 – Chaffin Creek SW11 – Unnamed bodies of water	The waterways in Section 3 are described as being primarily lowland freshwater systems, particularly in upstream areas. The downstream areas of Coldstream Creek, Chaffin creek and Champions Creek were assessed to have estuarine properties.	▪ Crows Nest Swamp located adjacent to the project ▪ SEPP 14 Coastal Wetland No.287 located 600m downstream of highway crossing Champions Creek ▪ SEPP 14 Coastal Wetland No.289 associated with Chaffin Creek is located 450m to west of the project ▪ SEPP 14 Wetland No. 292 is part of the Upper Coldstream wetlands, associated with Coldstream River and Pillar Valley Creek, located downstream and to the west of the project. ▪ Key fish habitats are assessed to be present for all named waterways and some smaller unnamed tributaries. Known and potential threatened aquatic species habitat is assessed to be present in Coldstream River, Black Snake Creek, Pillar Valley Creek and Chaffin Creek.

Source: Table 1 in Coffey Geotechnics (2014c).

Section 3: Surface Water Monitoring – Overview of Results

Physical properties

Temperature generally exhibited a gradual increase generally from the low teens (13-15°C) in winter up to middle 20s (around 25-27°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water creeks and tidal waterways.

Turbidity and total suspended solids (TSS) data varied greatly with no obvious correlation between high results and wet weather as would normally be anticipated. There was also a generally weak correlation between turbidity and TSS.

Chemical properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. Median pH levels were generally in the range of 5 to 7.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.05 to 0.08 mg/L. Total Nitrogen values were generally less than 1.0 mg/L.

Heavy metals

Heavy metals were generally below detection limits in all samples for all waterways.

Summary of Visual Observations and Sampling Results

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW01 Picanny Creek (Downstream) Section 3 Ch. 35,800	▪ Pheasant Creek is a small permanent water course, within the State Forest, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity during the monitoring program with slow flows to stagnant water generally observed. Moderate flows were observed during Round 2 (February) of the monitoring program. ▪ Water levels were high in Round 1 & 2 (January and February) and at low levels during Round 10 (October). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: 260-14mg/L ▪ TP: 0.01-0.07mg/L ▪ TN: 0.63-4.8mg/L ▪ DO: 4.16-9.12mg/L ▪ EC: 135-400µS/cm ▪ pH: 3.4-7.22 ▪ Temp: 10.8-27.2ºC ▪ NTU: 36-400
SW02 Pheasant Creek (Downstream) Section 3 Ch. 36,400	▪ Pheasant Creek is a small permanent water course, within the State Forest, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow flows observed. Stagnant water was recorded following dry weather in August - October (Round 8 – 10). There were moderate flows also observed during Round 2 of the monitoring program. Water levels were high January - February (Round 1 – 2) and low levels during the dry periods of August - October (Round 8 – 10). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5 -96mg/L ▪ TP: <0.01-0.11mg/L ▪ TN: 0.3-1.4mg/L ▪ DO: 4.12-8.97mg/L ▪ EC: 128.4-356µS/cm ▪ pH: 3.27-7.24 ▪ Temp: 25.7-14.2ºC ▪ NTU: 40.1-140
SW03 Unnamed tributary of Glenugie Creek (Downstream) Section 3 Ch. 39,700	▪ Unnamed tributary of Glenugie Creek is a small permanent water course, within private (Lot 7DP793765) rural grazing land property, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity during the monitoring program with generally slow flows to stagnant water recorded in August – October (Round 8 – 10). There were moderate flows	▪ O&G:<5 mg/L ▪ TSS: 7.4-130mg/L ▪ TP: <0.01-0.08mg/L ▪ TN: <0.2-1.4mg/L ▪ DO: 2.36-8.06mg/L ▪ EC: 218µS/cm-5.37mS/cm ▪ pH: 5.84-7.57 ▪ Temp: 12.3-24.9ºC ▪ NTU: 4.8-145

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
	observed during Round 2 (February) of the monitoring program. ▪ Water levels were high Round 1 & 2 (February) and low levels during August - October (Round 8 – 10). The remaining months were observed as normal water levels.	
SW04 Coldstream River (Upstream) Ch. 42,400	▪ Coldstream River is a small permanent water course, adjacent to Want Lane in the road reserve, up gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow flows to stagnant water recorded. ▪ Water levels were high during February (Round 1 – 2) and low levels during the dry periods of August - October (Round 8 – 10). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-50mg/L ▪ TP: 0.02-0.21mg/L ▪ TN: 0.3-2.5mg/L ▪ DO: 3.2-11.99mg/L ▪ EC: 7.82µs/cm-2.34mS/cm ▪ pH: 5.41-6.78 ▪ Temp: 12.8-26ºC ▪ NTU: 7.52-35.1
SW05 Coldstream River (Upstream) Ch. 43,000	▪ Permanent water course sampled beneath Sandy Crossing Bridge within the road reserve, up gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity during the monitoring program with generally slow flows observed. Moderate flows were also observed during Round 2, 11a & 11b (February & November) of the monitoring program. ▪ Water levels were high in Round 1, 2 & 11a (February & November). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-35mg/L ▪ TP: <0.01-0.11mg/L ▪ TN: 0.24-0.9mg/L ▪ DO: 3.15-8.37mg/L ▪ EC: 115.3-935µS/cm ▪ pH: 5.36-7.27 ▪ Temp: 12.9-25.2ºC ▪ NTU: 5.38-44.1
SW06 Pillar Valley Creek (Downstream) Ch. 46,400	▪ Pillar Valley Creek was a small permanent water course, within rural grazing land (private property, Lot 15 DP751378), down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during the monitoring program with slow flows to stagnant water generally observed. There were periods of moderate flows observed during Round 5b, 6b & 11a, which were all wet weather sampling events (May, July & November). ▪ Water levels were high from February to March & July (Round 1 – 4 & 6b) and low levels during Round 10 (October). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-16mg/L ▪ TP: <0.01-0.06mg/L ▪ TN: 0.015-2.1mg/L ▪ DO: 6.01-9.82mg/L ▪ EC: 120.4-458µS/cm ▪ pH: 3.11-7.09 ▪ Temp: 14.8-29.5ºC ▪ NTU: 11.428.2

Site Identifier/Waterway	***Summary of Visual Observations***	***Overview of Water Quality Sampling Results***
SW07 Black Snake Creek (Downstream) Ch. 46,700	▪ Black Snake Creek was a small ephemeral water course, within rural grazing land (private property, Lot 1 DP751378), down gradient of the proposed G2DP highway alignment. The Creek was dry during the Round 10 monitoring event (October). ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during the monitoring program with slow flows to stagnant water generally observed. There were also moderate flows observed during Round 2-4, 6b & 11a. ▪ Water levels were high from February – April, July & November (Round 1 – 4, 6b & 11a), the Creek was low in Round 8 & 9 (August & September) and dry during Round 10 (October). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-56mg/L ▪ TP: <0.01-0.04mg/L ▪ TN: >0.1-0.47mg/L ▪ DO: 7.98-10.15mg/L ▪ EC: 124.9-381µS/cm ▪ pH: 4.56-7.47 ▪ Temp: 14.5-27ºC ▪ NTU: 6.37-84.1
SW22 Unnamed Creek tributary of Ellis Swamp (Downstream) Ch. 50,300	▪ The small Creek was an ephemeral water course, sampled from the road reserve down gradient of the proposed G2DP highway alignment. The Creek was dry for the monitoring event in October (Round 10). ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during monitoring with slow flows to stagnant water generally observed. There were also moderate flows observed during Round 2-4, 6b & 11a. ▪ Water levels were high from February – April, July & November (Round 1 – 4, 6b & 11a), low in Round 8 & 9 (August & September) and dry during Round 10 (October). Normal water levels were observed in remaining months.	▪ O&G: <5-6.4mg/L ▪ TSS: <5-40mg/L ▪ TP: <0.01-0.08mg/L ▪ TN: 0.3-1.1mg/L ▪ DO: 2.55-9.70mg/L ▪ EC: 105.9-296µS/cm ▪ pH: 3.54-6.79 ▪ Temp: 12.5-25.5ºC ▪ NTU: 7.2-36.1
SW08 Chaffin Creek (Downstream) Ch. 52,500	▪ Chaffin Creek is a permanent water course, within rural grazing land (private property, Lot 44 DP751365), down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity during the monitoring program with generally slow flows observed, with stagnant water recorded following the dry weather August to October (Round 8 – 10). ▪ Water levels were high during February & July (Round 2 & 6b) and low levels during the dry periods of August to October (Round 8 – 10). The remaining months were observed as normal water levels.	▪ O&G: <5-5mg/L ▪ TSS: <5-13mg/L ▪ TP: <0.01-0.08mg/L ▪ TN: 1.5-0.3mg/L ▪ DO: 3.04-7.94mg/L ▪ EC: 104.4-336-µS/cm ▪ pH: 5.32-6.82 ▪ Temp: 14.8-30.3ºC ▪ NTU: 4.08-32.8

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW09 Unnamed tributary of Chaffin Creek (Downstream) Ch. 54,600	▪ Unnamed tributary of Chaffin Creek is a small permanent water course, within rural grazing land (private property Lot 108 DP751365), down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity throughout the monitoring program with generally slow flows to stagnant water observed. There were moderate flows observed during Round 1 – 4 & 6b (February – April & July). ▪ Water levels were high from February - April (Round 1 – 4), the Creek was low in Round 5, 8 - 10 (May & Aug - Oct). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-33mg/L ▪ TP: <0.01-0.05mg/L ▪ TN: 0.3-1.3mg/L ▪ DO: 1.92-8.77mg/L ▪ EC: 110.2-430µS/cm ▪ pH: 3.48-6.85 ▪ Temp: 12.9-24.9ºC ▪ NTU: 4.33-39.00
SW10 Champions Creek (Upstream) Ch. 57,200	▪ The small Creek was an ephemeral water course located within bush land (private property), up gradient of the proposed G2DP highway alignment. The Creek was dry for the monitoring event in October (Round 10) ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during the monitoring program with generally slow flows to stagnant water observed. There were moderate flows observed during Round 6b (July). ▪ Water levels were high from February – April & July (Round 1 – 4 & 6b), the Creek was normal in Round 5b & 11b (July and November) and dry during Round 10 (October). The remaining months were observed as low water levels	▪ O&G: <5mg/L ▪ TSS: <5-29mg/L ▪ TP: <0.01-0.12mg/L ▪ TN: 0.61-1.3mg/L ▪ DO: 2.46-6.74mg/L ▪ EC: 79.4-500µS/cm ▪ pH: 2.99-6.1 ▪ Temp: 11.4-25.2ºC ▪ NTU: 30.8-41.2
SW11 Unnamed body of water (Downstream)	▪ Unnamed body of water is a small permanent water course located within private property bushland (Lot 124 DP751365), down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow flows observed. Stagnant water was recorded in August to October (Round 8 – 10). ▪ Water levels were high in February (Round 1 – 2) and low levels during the dry periods of August to October (Round 8 – 10). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-16mg/L ▪ TP: <0.01-0.04mg/L ▪ TN: 0.15-0.6mg/L ▪ DO: 2.34-7.95mg/L ▪ EC: 119.3-290µS/cm ▪ pH: 5.17-6.46 ▪ Temp: 11-22.3ºC ▪ NTU: 4.04-25.3

Site Identifier/Waterway	***Summary of Visual Observations***	***Overview of Water Quality Sampling Results***
SW12 South Arm Clarence River (Tidal)	▪ South Arm Clarence River was sampled from within private property, to the west of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. Moderate flows during the wet weather event in July (Round 6b). ▪ Water levels were high in February and the remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-32mg/L ▪ TP: <0.01-0.15mg/L ▪ TN: 0.31-1.1mg/L ▪ DO: 0.49-10.64mg/L ▪ EC: 132.5µS/cm-6.26mS/cm ▪ pH: 2.7-7.42 ▪ Temp: 27.4-16.2ºC ▪ NTU: 3.95-48.1

Note: * Ch. = Highway Chainage

Section 3: Surface Water Monitoring – Sampling Statistics

	Units	**SECTION 3**							
		SW01 (SW3-01)							
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	52.40	65.34	14	260	21	57.20	-	
Total Phosphorus as P	mg/l	0.04	0.01	0.01	0.07	0.03	0.04	-	
Total Nitrogen as N	mg/l	1.09	1.07	0.19	4.8	0.8	1.10	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.17	1.38	4.16	9.12	7.6	8.16	6.30	
Conductivity	µs/cm	234.50	76.27	135.1	444	228	269.00	178.84	
pH		6.66	0.95	3.4	7.22	6.94	7.18	6.59	
Temperature	○C	20.17	4.83	10.8	27.2	20.8	24.20	-	
Turbidity	NTU	97.89	89.20	36.1	400	69.9	123.00	-	
		SW02 (SW3-02)							
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	38.83	28.30	2.5	96	28	60.00	-	
Total Phosphorus as P	mg/l	0.06	0.06	0.005	0.25	0.04	0.07	-	
Total Nitrogen as N	mg/l	0.83	0.37	0.21	1.4	0.86	1.22	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.95	1.47	4.12	8.97	7	8.14	5.96	
Conductivity	µs/cm	186.38	60.98	128.4	356	167.1	221.36	141.86	
pH		6.51	1.01	3.27	7.24	6.89	7.05	6.26	
Temperature	○C	19.46	4.85	8.9	25.7	21.5	23.62	-	
Turbidity	NTU	91.21	31.23	40.1	140	95.3	117.80	-	

	Units	SECTION 3							
SW03 (SW3-03 AND SW3-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	45.53	41.96	7.4	130	42	67.80	-	
Total Phosphorus as P	mg/l	0.04	0.06	0.005	0.25	0.02	0.06	-	
Total Nitrogen as N	mg/l	0.69	0.32	0.1	1.4	0.7	0.92	-	
Dissolved Oxygen	mg/l	6.05	2.06	2.36	9.4	6.66	7.79	3.82	
Conductivity	µs/cm	792.30	526.45	204.4	1766	735	1286.00	278.00	
pH		7.03	0.43	5.84	7.57	7.01	7.36	6.80	
Temperature	°C	19.53	4.44	12.3	24.9	20.6	23.54	-	
Turbidity	NTU	69.54	53.43	4.8	145	74.8	123.20	-	
SW04 (SW3-05 and SW3-06)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	14.10	11.99	2.5	50	10	16.80	-	
Total Phosphorus as P	mg/l	0.06	0.07	0.02	0.25	0.03	0.05	-	
Total Nitrogen as N	mg/l	1.13	0.61	0.3	2.5	0.82	1.52	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.20	2.45	2.17	11.99	6.44	7.27	3.92	
Conductivity	µs/cm	736.49	564.46	7.82	1812	492.5	1115.60	297.60	
pH		6.15	0.40	5.41	6.78	6.15	6.48	5.83	
Temperature	°C	19.85	4.99	12.8	26	20.4	24.82	-	
Turbidity	NTU	16.73	6.62	7.25	35.1	16.5	19.16	-	
SW05 (SW3-07 and SW3-08)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	8.27	10.01	2.5	35	2.5	10.80	-	
Total Phosphorus as P	mg/l	0.05	0.06	0.005	0.25	0.03	0.06	-	
Total Nitrogen as N	mg/l	0.64	0.33	0.24	1.6	0.6	0.74	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.59	1.64	3.15	8.37	7.11	8.15	6.22	
Conductivity	µs/cm	264.02	202.22	115.3	935	188.9	336.00	15.18	
pH		6.48	0.47	5.36	7.27	6.57	6.80	7.26	
Temperature	°C	19.85	4.89	12.9	27	20.3	24.18	-	
Turbidity	NTU	15.03	9.92	5.38	44.1	13	17.80	-	
SW06 (SW3-09 and SW3-10)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	8.23	4.48	2.5	16	7.5	11.60	-	
Total Phosphorus as P	mg/l	0.04	0.06	0.005	0.25	0.03	0.04	-	
Total Nitrogen as N	mg/l	0.63	0.45	0.015	2.1	0.6	0.72	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	8.33	1.35	6.01	9.82	8.55	9.66	7.33	
Conductivity	µs/cm	233.88	112.09	120.4	522	182.6	257.40	172.78	

	Units	SECTION 3							
pH		6.18	0.95	3.11	7.09	6.4	6.76	5.93	
Temperature	○C	21.07	4.91	14.7	29.5	22.2	25.76	-	
Turbidity	NTU	16.34	5.79	7.46	28.2	16.3	19.82	-	
SW07 (SW3-11 and SW3-12)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	16.29	17.20	2.1	56	8.75	29.80	-	
Total Phosphorus as P	mg/l	0.04	0.06	0.005	0.25	0.03	0.04	-	
Total Nitrogen as N	mg/l	0.27	0.11	0.05	0.4	0.3	0.35	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	8.92	0.92	7.74	10.15	8.585	9.98	8.14	
Conductivity	µs/cm	173.44	64.90	113.2	381	160.55	183.26	134.28	
pH		6.30	0.77	4.56	7.47	6.505	6.81	5.79	
Temperature	○C	20.51	4.28	14.5	27	21.4	24.40	-	
Turbidity	NTU	23.80	20.62	6.37	84.1	14.85	33.92	-	
SW22 (SW3-13 and SW3-14)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.78	1.04	2.5	6.4	2.5	2.50	-	
Suspended Solids	mg/l	11.96	10.27	2.5	40	9.75	16.80	-	
Total Phosphorus as P	mg/l	0.05	0.06	0.005	0.25	0.025	0.05	-	
Total Nitrogen as N	mg/l	0.64	0.26	0.3	1.1	0.555	0.94	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.06	2.42	1.89	9.7	6.46	7.90	3.74	
Conductivity	µs/cm	176.71	51.55	105.9	296	173.65	203.52	134.16	
pH		5.94	0.86	3.54	6.79	6.315	6.51	5.41	
Temperature	○C	19.74	4.64	12.5	25.5	20.4	24.10	-	
Turbidity	NTU	12.14	7.93	7.2	36.1	9.185	13.44	-	
SW08 (SW3-15 and SW3-16)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.67	0.65	2.5	5	2.5	2.50	-	
Suspended Solids	mg/l	6.62	2.97	2.5	13	6	7.90	-	
Total Phosphorus as P	mg/l	0.05	0.06	0.005	0.25	0.03	0.06	-	
Total Nitrogen as N	mg/l	0.68	0.28	0.3	1.5	0.62	0.81	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.21	1.54	3.04	7.94	6.43	7.76	5.25	
Conductivity	µs/cm	203.01	60.63	104.4	336	190.3	244.60	160.80	
pH		6.19	0.49	5.32	6.82	6.31	6.72	5.73	
Temperature	○C	21.77	5.61	14.8	30.3	23.2	26.26	-	
Turbidity	NTU	14.75	7.71	4.08	32.8	14.1	19.72	-	
SW09 (SW3-17 and SW3-18)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	11.80	11.54	2.5	33	6.5	25.00	-	
Total Phosphorus as P	mg/l	0.03	0.06	0.005	0.25	0.02	0.02	-	

	Units	SECTION 3							
Total Nitrogen as N	mg/l	0.56	0.27	0.3	1.3	0.51	0.72	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.10	1.91	1.92	8.77	6.53	7.81	4.71	
Conductivity	µs/cm	216.01	90.73	110.2	430	204.6	286.00	143.86	
pH		5.65	0.79	3.48	6.85	5.65	6.17	5.30	
Temperature	°C	19.36	4.13	12.9	24.9	20.5	22.92	-	
Turbidity	NTU	14.33	9.95	4.33	39	13.2	17.90	-	
SW10 (SW3-19 and SW3-20)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	16.54	7.98	2.5	29	17	23.60	-	
Total Phosphorus as P	mg/l	0.05	0.06	0.005	0.25	0.035	0.05	-	
Total Nitrogen as N	mg/l	0.90	0.18	0.61	1.3	0.91	1.00	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.91	1.41	2.46	6.74	5.035	6.16	3.30	
Conductivity	µs/cm	232.77	116.47	79.4	500	206.2	314.20	142.36	
pH		5.15	0.97	2.99	6.1	5.46	5.84	4.58	
Temperature	°C	19.26	4.84	11.4	25.2	21.5	23.16	-	
Turbidity	NTU	19.53	10.27	3.08	41.2	20.15	26.10	-	
SW11 (SW3-21 and SW3-22)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	4.79	4.25	2.5	16	2.5	8.26	-	
Total Phosphorus as P	mg/l	0.03	0.06	0.005	0.25	0.02	0.02	-	
Total Nitrogen as N	mg/l	0.38	0.13	0.15	0.6	0.4	0.50	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.74	1.60	2.34	7.95	6.05	7.26	4.19	
Conductivity	µs/cm	188.82	45.99	119.3	290	188.2	212.20	158.00	
pH		5.98	0.42	5.17	6.46	6.05	6.31	5.66	
Temperature	°C	18.40	4.09	11	22.3	20.8	21.84	-	
Turbidity	NTU	9.43	5.48	4.04	25.3	7.05	11.26	-	
SW12 (SW3-23)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	13.40	9.30	2.5	32	10	19.60	-	
Total Phosphorus as P	mg/l	0.07	0.06	0.005	0.25	0.06	0.09	-	
Total Nitrogen as N	mg/l	0.63	0.24	0.31	1.1	0.6	0.80	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.67	2.68	0.49	10.64	8.43	9.43	5.83	
Conductivity	µs/cm	366.75	315.33	132.5	1232	257	396.40	172.00	
pH		6.50	1.14	2.7	7.42	6.76	7.14	6.37	
Temperature	°C	22.12	4.50	16.2	27.4	23.1	26.36	-	
Turbidity	NTU	15.29	11.72	3.95	48.1	11.5	21.82	-	

Section 3: Groundwater Monitoring – Water Quality Overview

Of the 51 bores monitored, two bores, PZ06 and PZ07, remained dry throughout the monitoring program with no data collected.

Electrical Conductivity

Values are indicative of freshwater to brackish / saline groundwater conditions with an average salinity ranging between 91 µS/cm (PZ21) to 9,108 µS/cm (PZ09). Generally well locations with shallower water levels (<5.0m below ground level) showed larger standard deviations than wells with standing water levels at greater depths.

pH

pH of groundwater in Section 3 show average values ranging from 3.8 to 7.69. A total of 28 locations had an average pH < 6.0 which suggests that acidic to slightly acidic groundwater is present in about half of the monitoring well locations in Section 3. Little variation occurs in pH with 10 of the 50 wells reporting a standard deviation value > 1 pH unit.

Temperature

The average temperature values for the monitoring locations in Section 3 ranged between 20.03°C to 23°C. The variation in water average temperature values throughout Section 3 likely to be attributable to seasonal temperature changes and the variable depth of groundwater from the ground surface.

Summary Statistics for Groundwater Physico-Chemical Monitoring

Cut/Fill Number	*Borehole Identifier*	Electrical Conductivity (µS/cm)				pH				Temp. (°C)
		*Med.**	*SD***	*P80*	*P20*	*Med.**	*SD***	*P80*	*P20*	*Med.**
Cut 3-5	PZ05	8175	657	8684	8046	6.86	0.16	6.98	6.78	20.05
	PZ06	Dry								
Cut 3-6	PZ07	Dry								
	PZ08	6490	335	6660	6320	7.02	0.14	7.10	6.95	22.60
Cut 3-7	PZ09	9175	408	9326	8916	6.86	0.19	7.02	6.78	21.95
	PZ10	8695	849	9270	7968	6.78	0.15	6.88	6.72	22.15
Fill F3-10B	PZ13	947	587	1325	412	6.63	0.30	6.87	6.44	20.90
	PZ14	1821	1858	3410	235	6.39	0.53	6.80	6.01	21.75
Fill F3-10C	PZ15	3580	2255	5140	1953	6.32	2.40	8.29	5.51	20.80
	PZ16	1624	1571	2932	240	6.24	0.76	6.95	5.78	20.70
Fill F3-11A	PZ17	424	114	528	375	5.40	0.31	5.61	5.22	20.80
	PZ18	1313	231	1475	1141	5.88	0.51	6.33	5.45	22.05
Fill F3-11B	PZ19	437	196	514	265	6.65	0.31	6.80	6.39	21.30
	PZ20	831	384	1123	488	6.56	2.59	8.67	6.20	21.60
Fill F3-11C	PZ21	81	29	106	72	5.48	0.75	5.89	4.94	22.15
	PZ22	219	94	294	193	6.22	1.45	7.38	5.56	21.85
Fill F3-11D	PZ23	184	25	193	167	6.47	1.40	7.44	5.81	23.00
	PZ24	516	92	598	493	5.52	0.60	5.86	5.18	22.15
Fill F3-11E	PZ25	217	55	262	190	5.64	0.50	5.79	5.30	20.00
	PZ26	272	36	300	253	5.59	0.79	6.14	5.08	20.20
Cut C3-11	PZ27	143	29	156	117	5.13	0.72	5.47	4.53	20.60
	PZ28	172	11	179	165	4.38	0.41	179.22	165.98	21.15
Cut C3-15	PZ29	325	24	341	302	5.18	0.64	5.38	4.60	20.45
	PZ30	2855	592	3216	2350	5.59	0.34	5.88	5.46	21.35

Cut/Fill Number	Borehole Identifier	Electrical Conductivity (µS/cm)				pH				Temp. (°C)
		Med.*	SD**	P80	P20	Med.*	SD**	P80	P20	Med.*
Fill F3-16A	PZ31	116	32	131	88	5.59	0.89	6.17	4.96	20.80
	PZ32	2205	869	2970	1949	4.72	1.02	5.46	4.26	21.80
Fill F3-16B	PZ34	1137	541	1367	727	6.05	0.36	6.18	5.77	21.40
Cut C3-16	PZ35	177	15	190	169	5.05	0.57	5.17	4.59	21.40
	PZ36	1061	319	1281	940	5.22	0.53	5.62	4.89	21.40
Cut C3-17	PZ37	1103	179	1161	987	6.25	0.33	6.31	5.98	21.50
	PZ38	2172	480	2330	1795	6.75	0.18	6.85	6.60	21.80
Cut C3-18	PZ39	275	141	290	160	3.96	0.46	4.07	3.60	20.40
	PZ40	663	481	837	488	5.23	3.03	5.37	5.08	20.90
Fill F3-19C	PZ41	409	104	413	324	6.38	0.49	6.66	6.01	20.85
Cut C3-19	PZ43	592	39	622	559	4.66	0.39	4.74	4.32	21.25
	PZ44	132	26	150	108	4.98	0.65	5.29	4.43	21.55
Cut C3-21	BH1139	231	6	234	226	4.94	0.40	5.08	4.64	20.70
	PZ45	249	32	258	220	5.01	0.45	5.35	4.80	20.60
Cut C3-26	PZ46	408	109	499	368	5.97	0.75	6.17	5.33	20.30
	PZ47	861	167	967	767	6.53	0.40	6.64	6.17	20.65
Cut C3-28	PZ48	762	201	823	592	6.54	0.45	6.75	6.16	20.30
	PZ49	187	4	190	184	4.06	0.49	4.30	3.73	20.00
Cut C3-30	BH1159	1472	175	1611	1434	3.95	0.35	4.24	3.67	23.10
	BH1170	261	37	292	249	7.62	1.14	8.32	7.03	22.75
	PZ50	830	104	858	750	6.84	0.24	6.93	6.68	22.10
Cut C3-31	PZ51	963	512	1086	744	5.66	2.87	5.79	5.65	21.50
	BH1187	438	126	539	421	5.00	0.56	5.22	4.64	21.50
Cut C3-32	BH1197	387	83	457	363	6.40	0.44	6.49	6.06	20.95
	PZ52	478	90	544	407	6.44	0.56	6.51	5.98	21.00
Cut C3-33	BH1200	592	234	180	146	5.73	2.81	5.68	5.56	20.75
	PZ53	172	85	807	456	5.52	2.78	6.09	5.66	20.40

Note: * Med. = Median
** DS = Standard Deviation

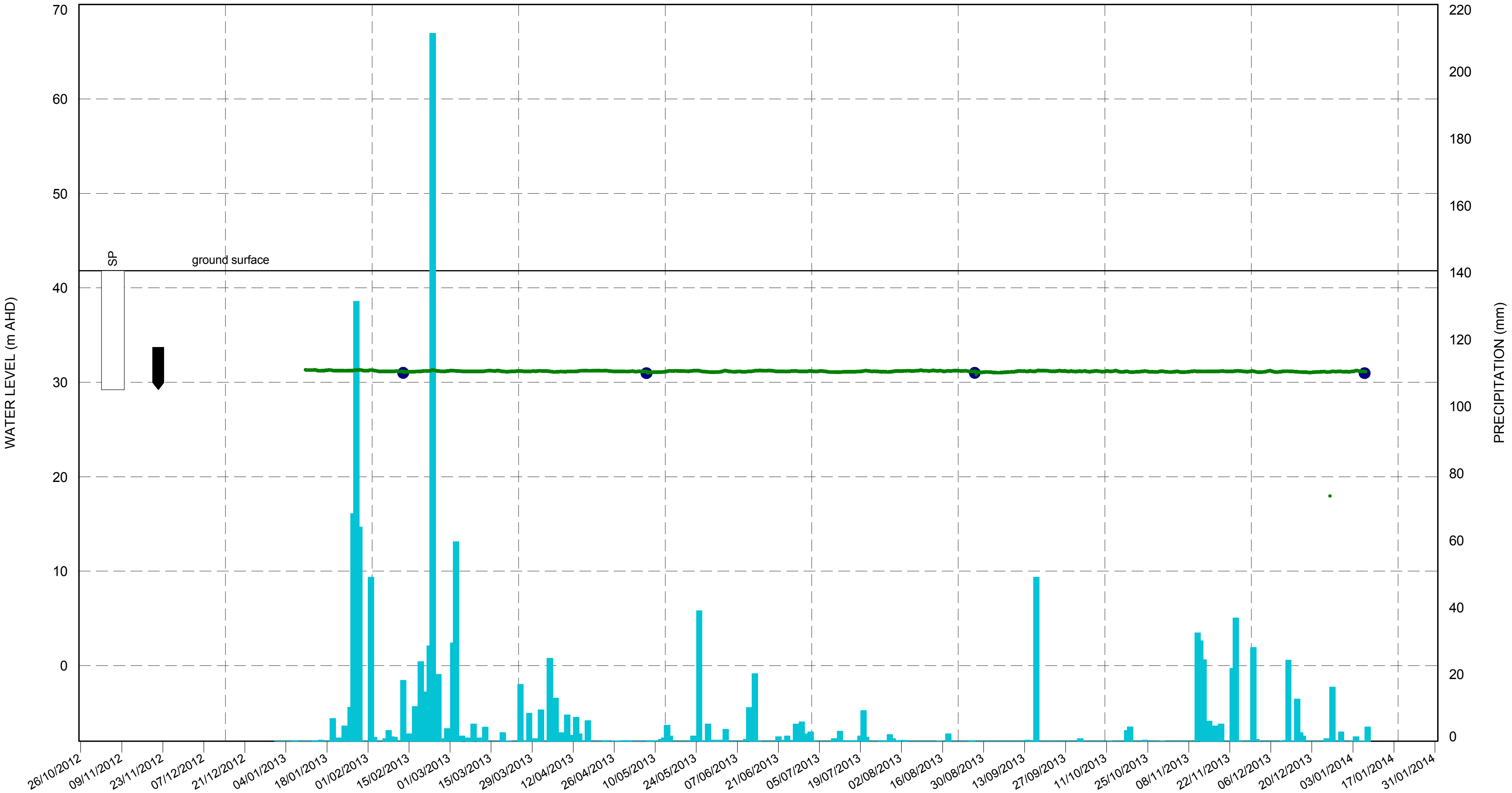
Section 3: Groundwater Monitoring – Levels

The standing water level (SWL) values averaged between 0.04m above the ground surface (PZ26) and 27.21m below ground surface (PZ51). In general, the SWLs observed within the planned fill areas monitored within Section 3 were noted to be close to the ground surface indicating shallow groundwater (<5m bgs – below ground surface) while the SWLs observed within the planned cut areas were noted at >5m bgs depth. The long term monitoring data indicates that the groundwater levels throughout much of Section 3 are influenced by large rainfall events (e.g. over 100mm rainfall event in January 2013). It should be noted the SWLs are relative to the topography of the monitoring location.

Summary of Groundwater Level Monitoring – Section 3 G2DP Upgrade

Cut/Fill Number	***Monitoring Location***	***Borehole Depth***	***Typical SWL (m below ground level)***		
			AVG	***MED***	***SD***
Cut 3-5	PZ05	12.6	10.84	10.84	0.02
	PZ06	16	Dry		
Cut 3-6	PZ07	8	Dry		
	PZ08	12	11.40	11.40	0.04
Cut 3-7	PZ09	13.95	11.62	11.63	0.05
	PZ10	13.83	11.84	11.81	0.20
Fill F3-10B	PZ13	6	1.07	1.06	0.46
	PZ14	6	0.75	0.66	0.28
Fill F3-10C	PZ15	6.16	1.54	1.39	0.40
	PZ16	6.1	1.74	1.62	0.37
Fill F3-11A	PZ17	6.11	2.92	2.80	0.28
	PZ18	6	0.24	0.27	0.29
Fill F3-11B	PZ19	6.14	1.06	1.12	0.47
	PZ20	6.06	1.48	1.58	0.57
Fill F3-11C	PZ21	6.09	1.34	1.52	0.57
	PZ22	6	0.50	0.55	0.20
Fill F3-11D	PZ23	6.07	0.69	0.69	0.27
	PZ24	6.04	0.47	0.57	0.29
Fill F3-11E	PZ25	6	1.08	1.11	0.27
	PZ26	5.9	-0.04 (SWL above ground level)	-0.08 (SWL above ground level)	0.26
Cut C3-11	PZ27	19	8.69	8.61	0.55
	PZ28	15.27	8.80	8.85	0.39
Cut C3-15	PZ29	16.1	3.62	3.66	0.62
	PZ30	12.18	6.72	6.62	0.26
Fill F3-16A	PZ31	6	0.69	0.71	0.18
	PZ32	6.05	4.03	4.10	0.14
Fill F3-16B	PZ34	6	1.35	1.74	1.16
Cut C3-16	PZ35	17	8.93	8.94	0.25
	PZ36	15.92	11.81	11.77	0.36
Cut C3-17	PZ37	20	16.90	16.96	0.28
	PZ38	18.1	14.63	14.65	0.13
Cut C3-18	PZ39	13.05	7.26	7.21	0.65
	PZ40	11	9.89	9.89	0.74
Fill F3-19C	PZ41	6	0.48	0.47	0.26
Cut C3-19	PZ43	15.15	11.91	11.89	0.31
	PZ44	9	4.02	3.90	1.13
Cut C3-21	BH1139	22	7.62	7.87	1.61
	PZ45				
Cut C3-26	PZ46	17.05	9.17	12.20	6.15
	PZ47	15.3	10.39	10.38	0.07
Cut C3-28	PZ48	14	11.34	11.27	0.27
	PZ49	15	11.27	11.32	0.36
Cut C3-30	BH1159	15.1	9.03	8.98	0.68
	BH1170	24.25	8.88	8.88	0.24
	PZ50	25	13.68	13.55	0.49
Cut C3-31	PZ51	28	27.21	26.99	0.53
	BH1187	25	17.37	17.42	0.22

Cut/Fill Number	Monitoring Location	Borehole Depth	Typical SWL (m below ground level)		
			AVG	MED	SD
Cut C3-32	BH1197	26.5	6.70	7.06	1.16
	PZ52	12	9.23	9.12	0.39
Cut C3-33	BH1200	37	26.37	26.73	0.99
	PZ53	6	4.19	4.43	1.69



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from
Bureau of Meteorology
website (www.bom.gov.au)
Grafton Airport AWS

Surface RL: 41.82 m AHD
Borehole Depth: 12.60 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 12.60 m bgl
RL of Tip: 29.22 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 12.60 m bgl
RL of Tip: 29.69 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ5**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H13** | rev:

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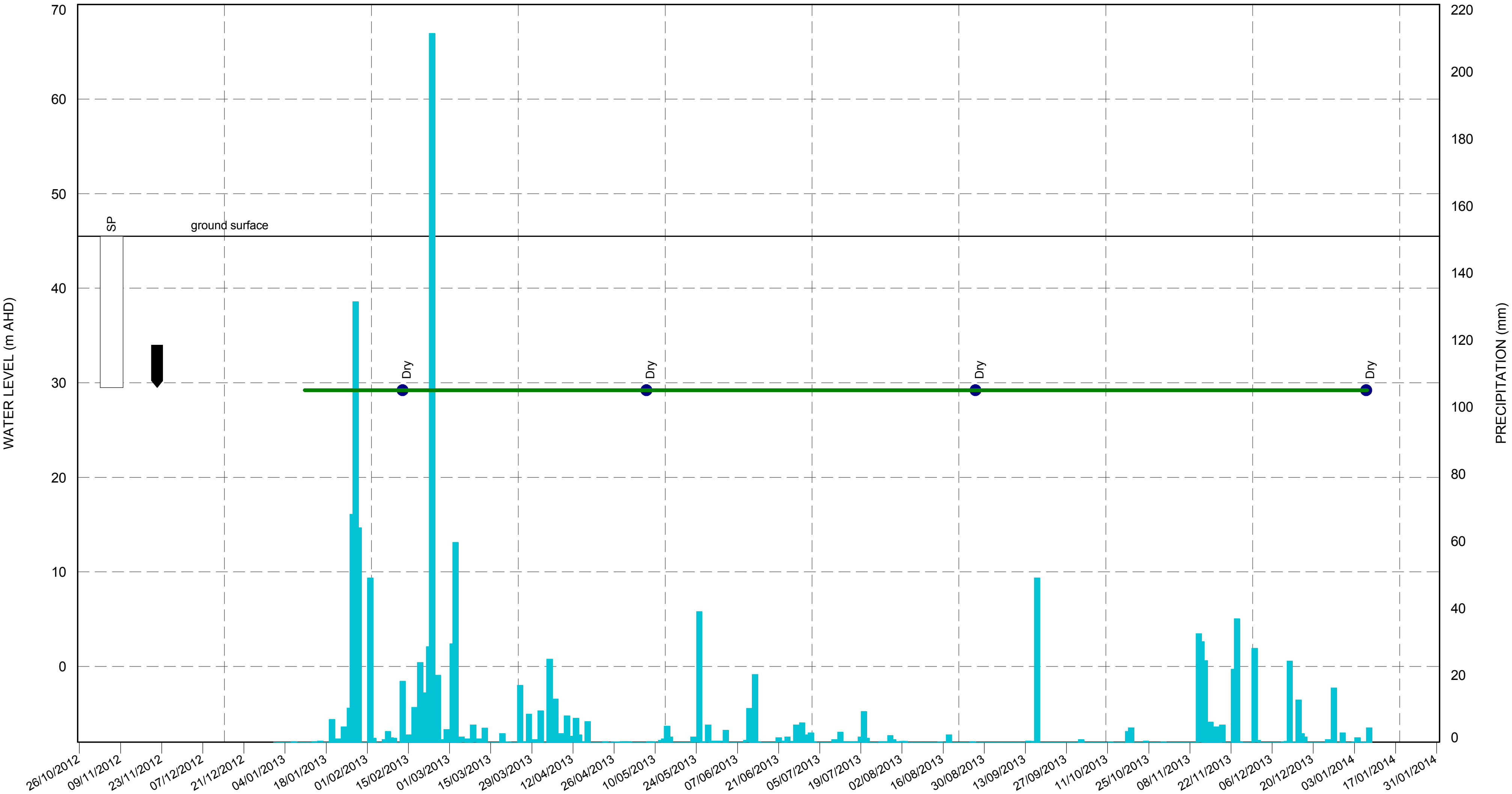


Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 45.49 m AHD
Borehole Depth: 16.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 16.00 m bgl
RL of Tip: 29.49 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 16.00 m bgl
RL of Tip: 29.22 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

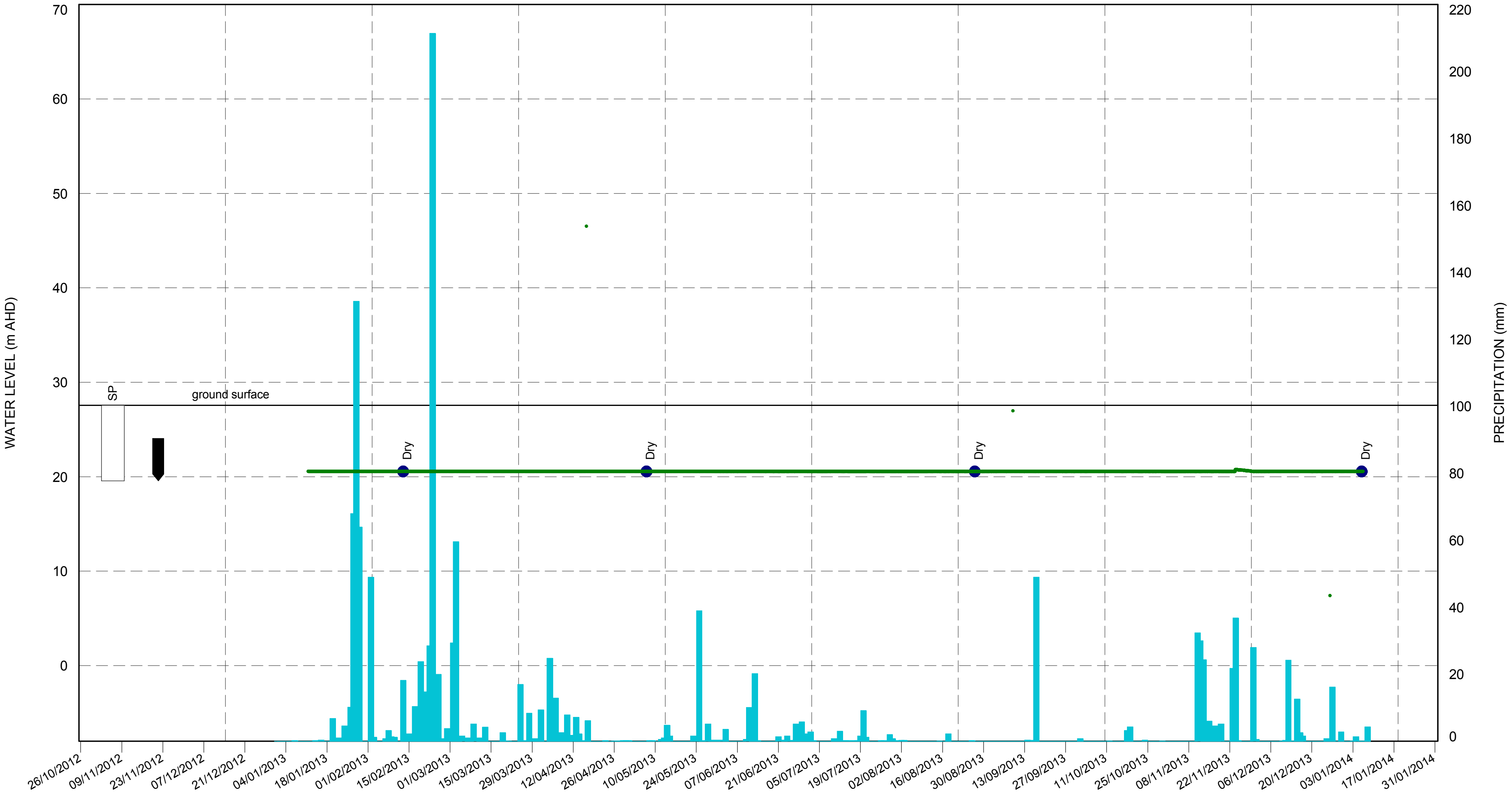
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ6**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H14** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 27.56 m AHD
Borehole Depth: 8.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 8.00 m bgl
RL of Tip: 19.56 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 8.00 m bgl
RL of Tip: 20.56 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

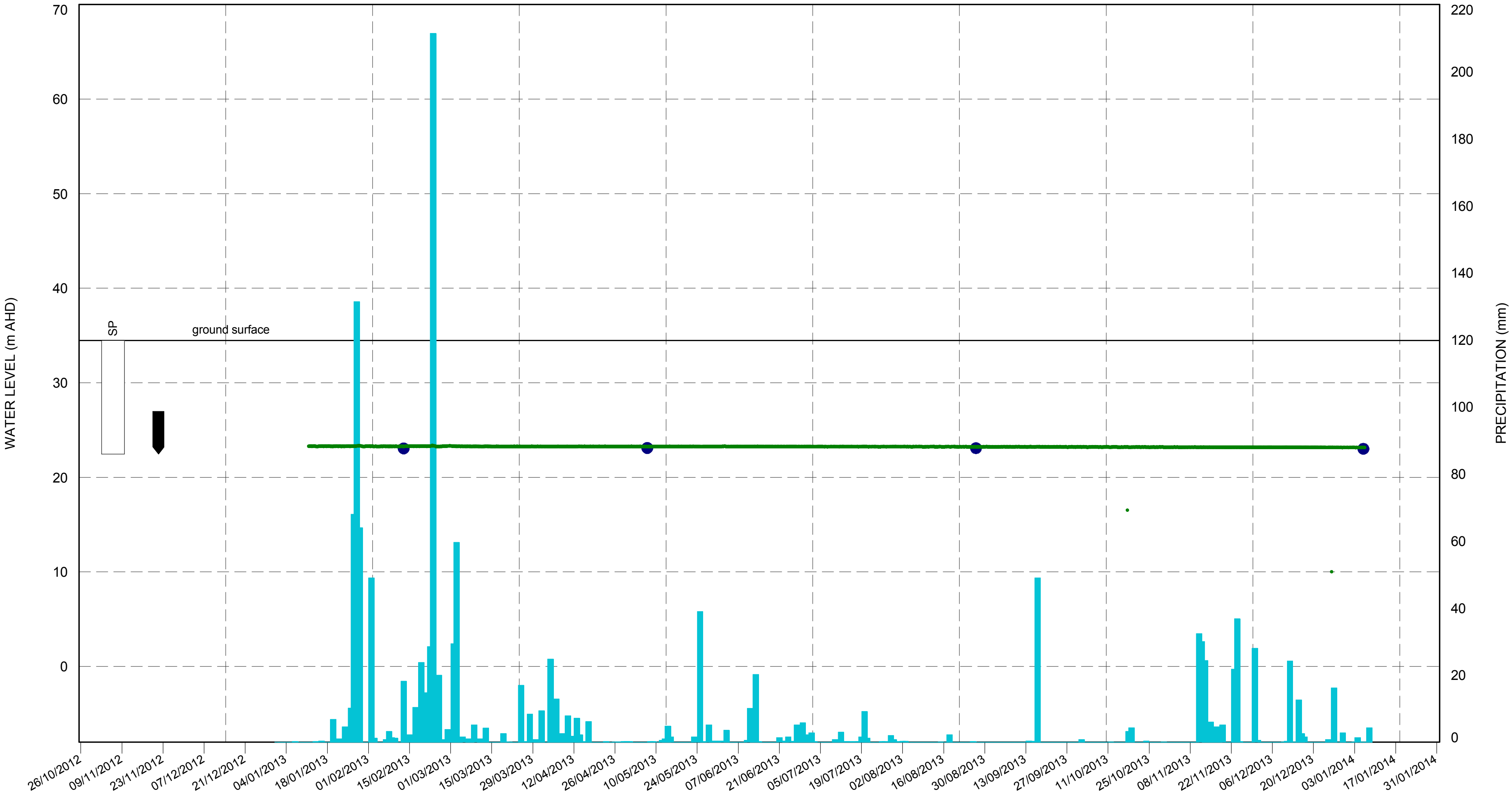
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ7**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H15** | rev:



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Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 34.47 m AHD
Borehole Depth: 12.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 12.00 m bgl
RL of Tip: 22.47 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 12.00 m bgl
RL of Tip: 22.84 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

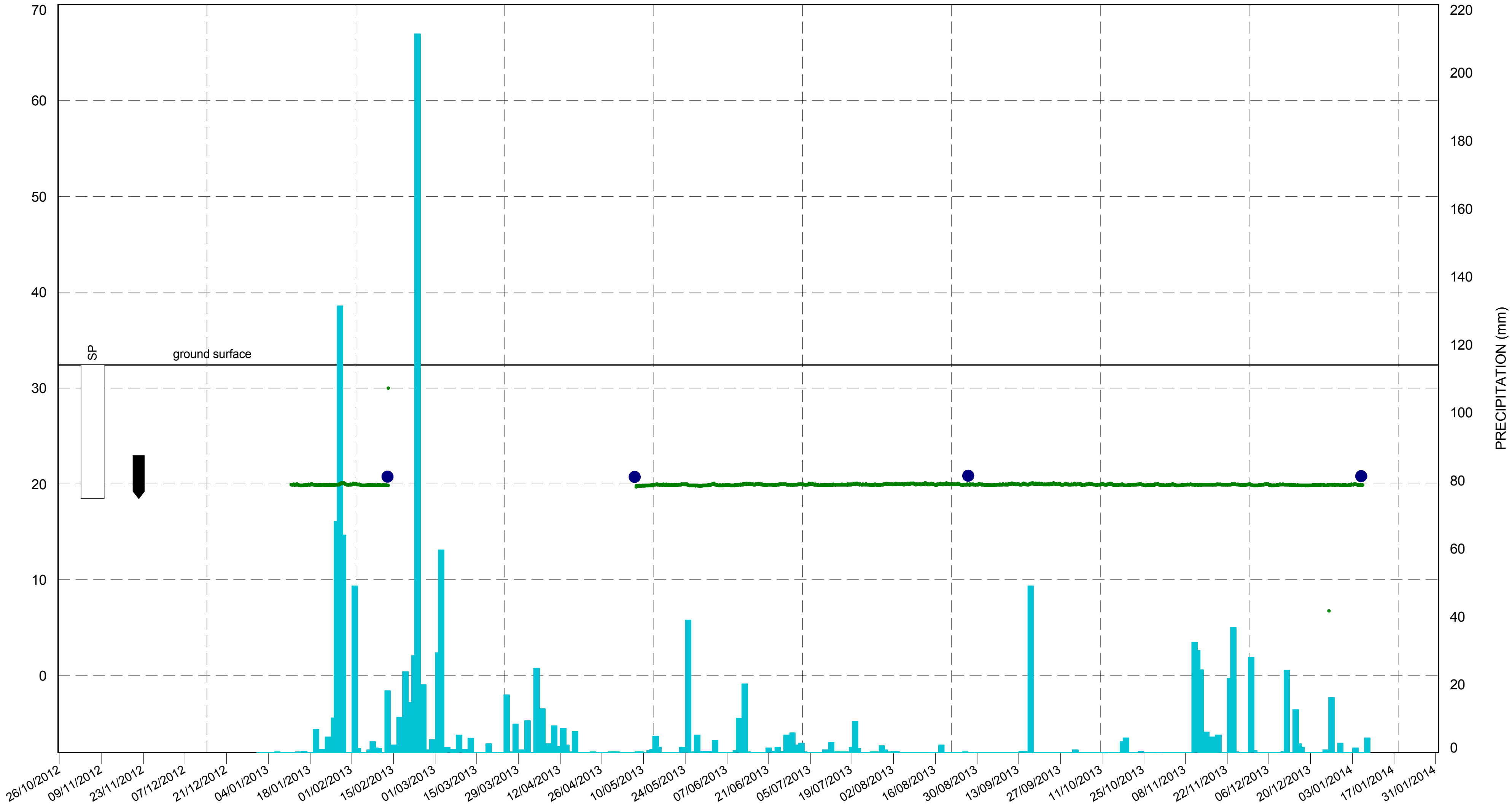
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ8**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H16** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:06

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 32.42 m AHD
Borehole Depth: 13.95 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 13.95 m bgl
RL of Tip: 18.47 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 13.95 m bgl
RL of Tip: 17.59 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

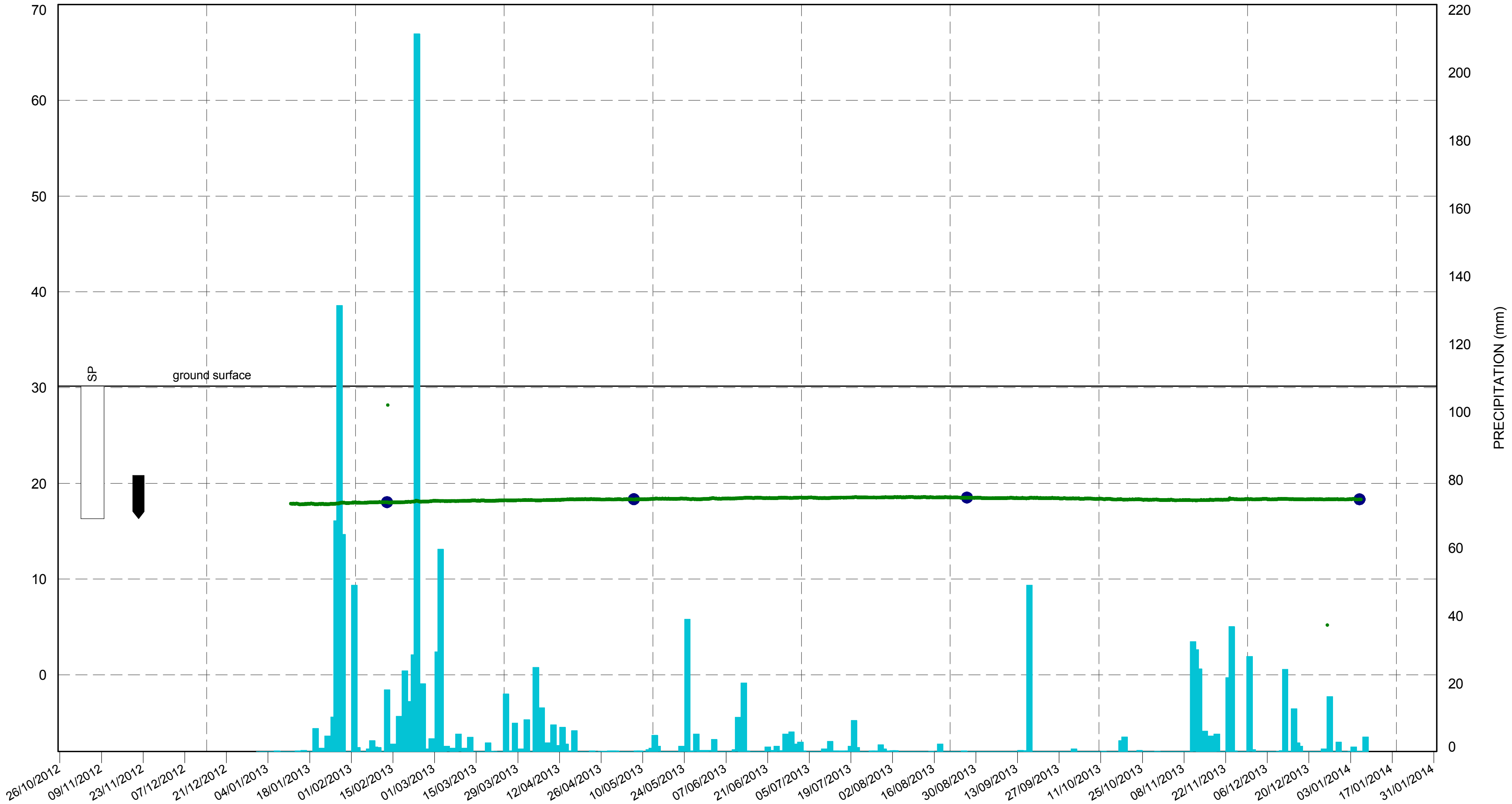
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ9**

project no	fig no:	rev:
GEOTCOFH03059AA-AO	FIGURE H17	

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:07



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 30.15 m AHD
Borehole Depth: 13.83 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 13.83 m bgl
RL of Tip: 16.32 m AHD

━ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 13.83 m bgl
RL of Tip: 16.74 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

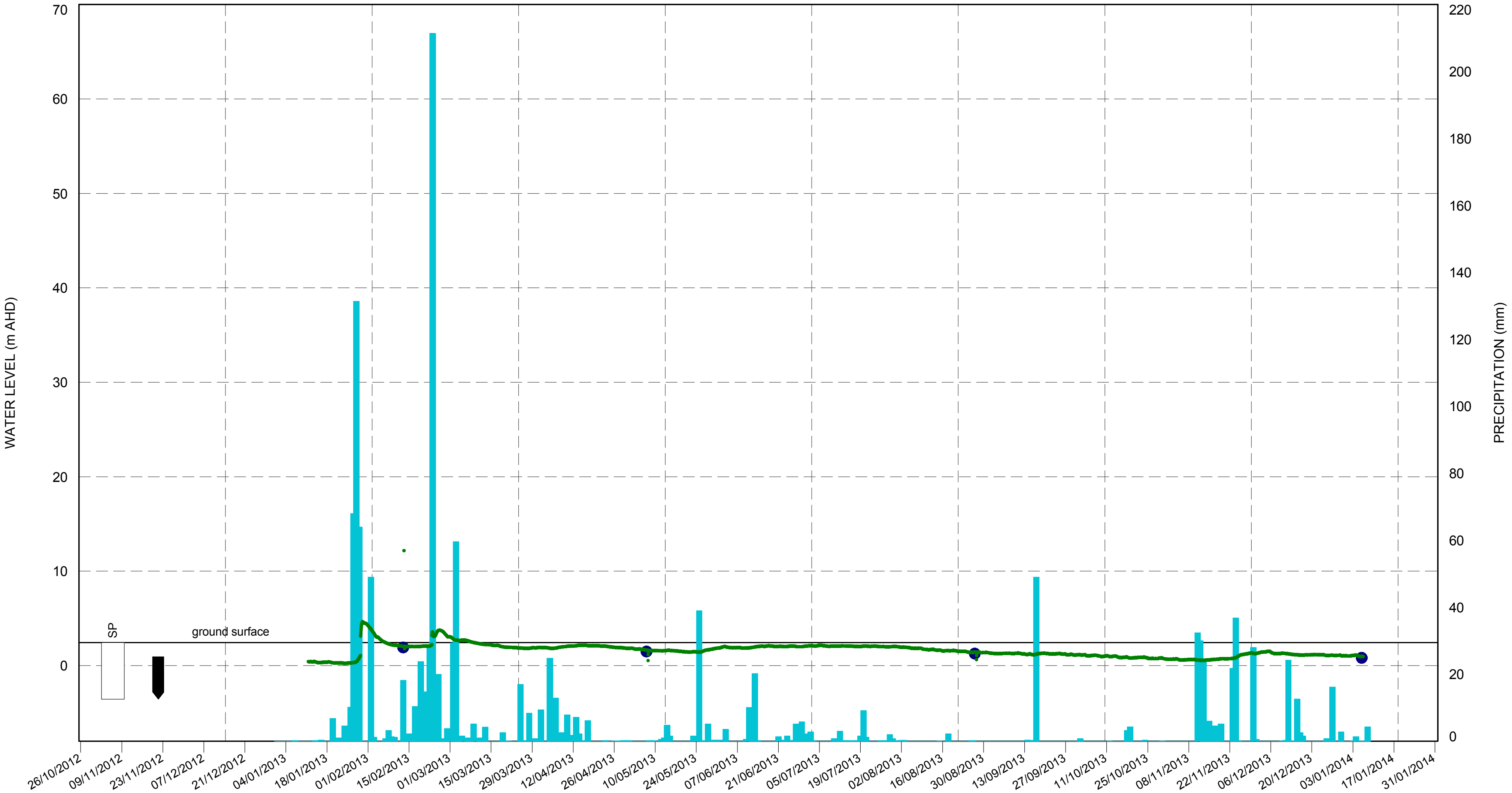
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ10

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H18 | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 2.45 m AHD
Borehole Depth: 6.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.55 m AHD

━: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.94 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

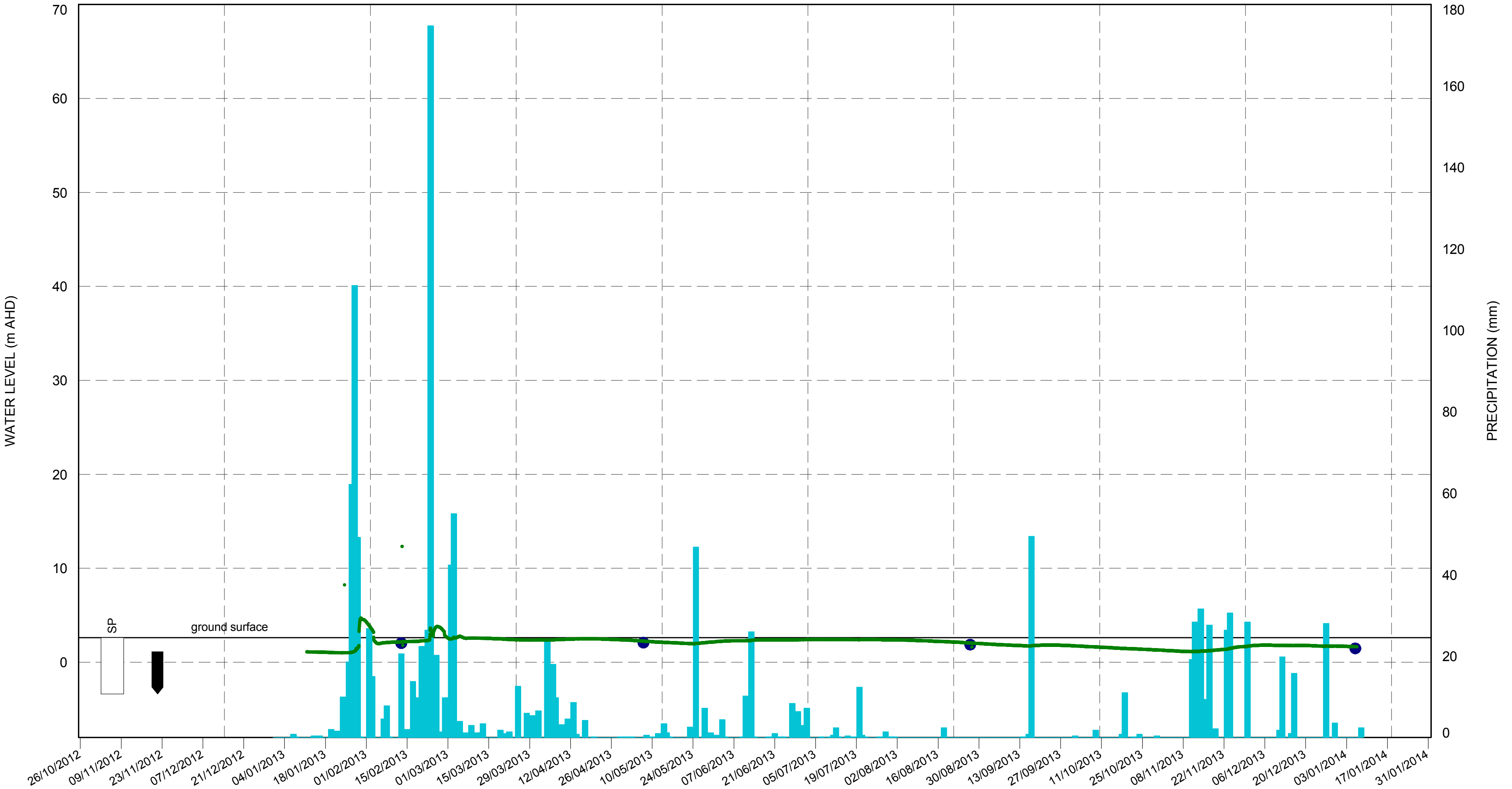
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ13**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H19** | rev:



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 2.62 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.38 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.81 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

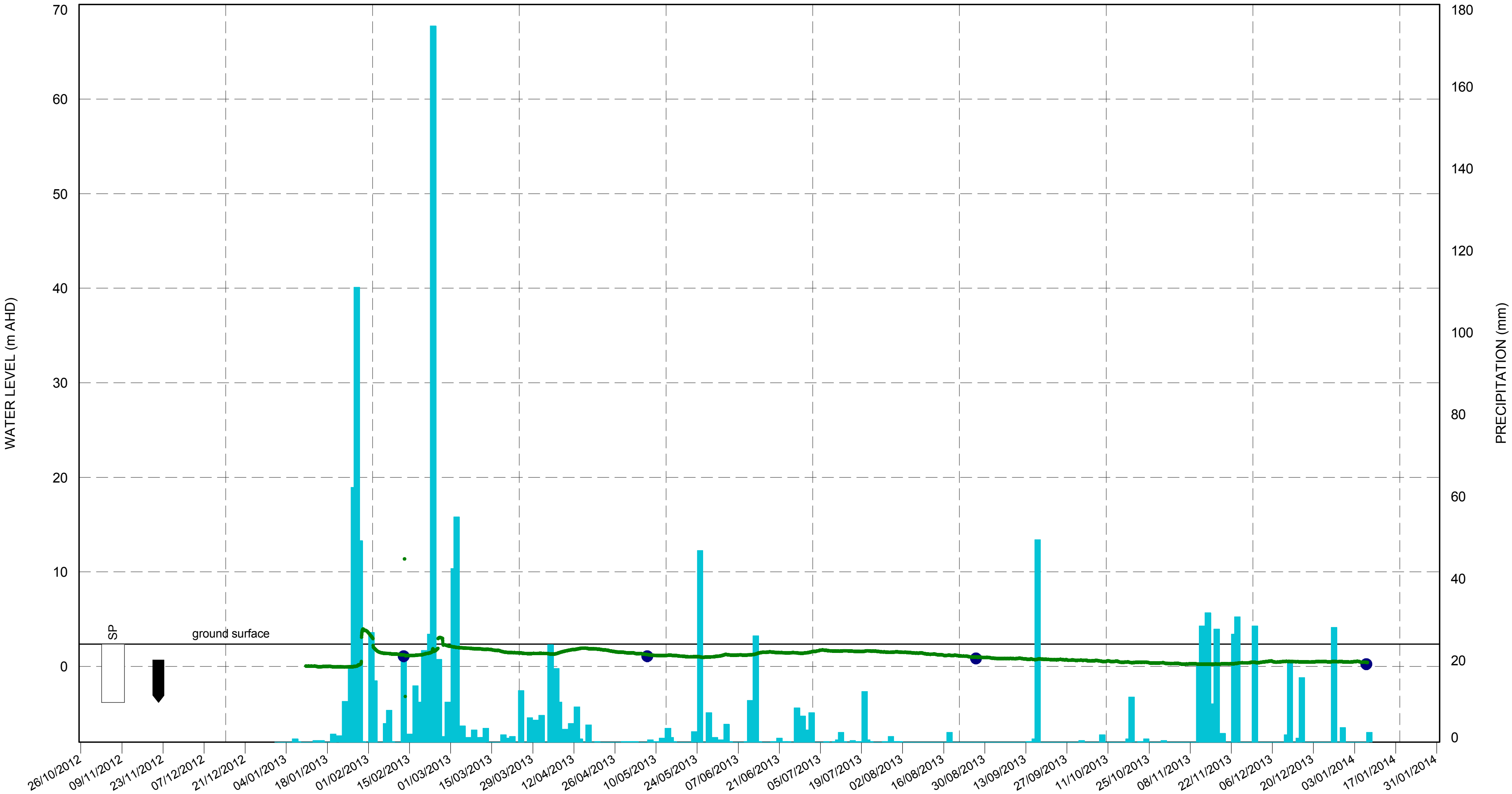
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ14**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H20** | rev:



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 2.36 m AHD
Borehole Depth: 6.16 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.16 m bgl
RL of Tip: -3.80 m AHD

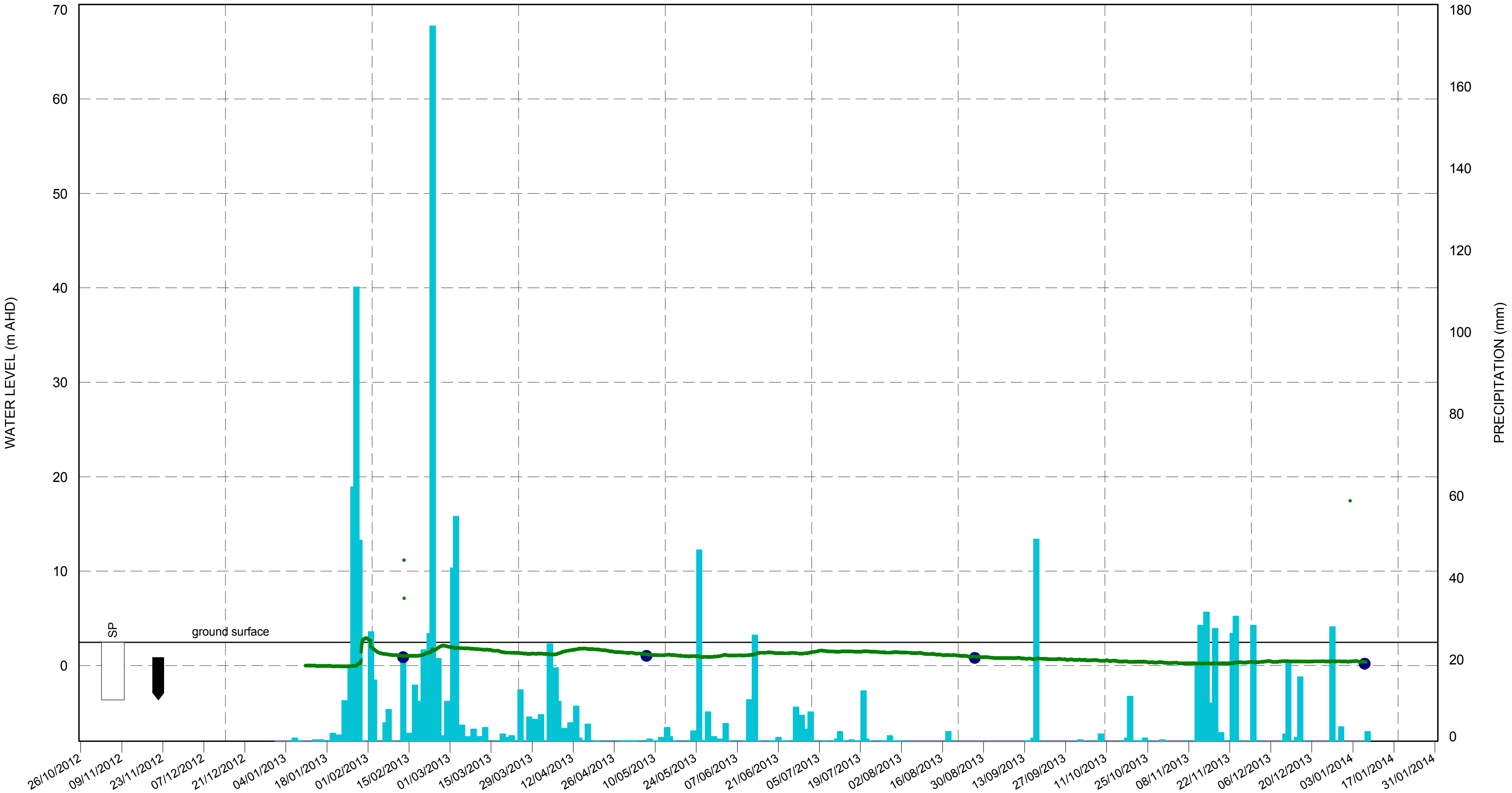
▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.16 m bgl
RL of Tip: -3.22 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH	client:	Roads and Maritime Services
approved	AB	project:	Glenugie to Devils Pulpit Groundwater Monitoring
date	10/03/2014	title:	GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ15
scale	AS SHOWN		
original size	A4	project no: GEOTCOFH03059AA-AO	fig no: FIGURE H21 rev:

coffey

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:12



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 2.48 m AHD
Borehole Depth: 6.10 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.10 m bgl
RL of Tip: -3.62 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.10 m bgl
RL of Tip: -3.07 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

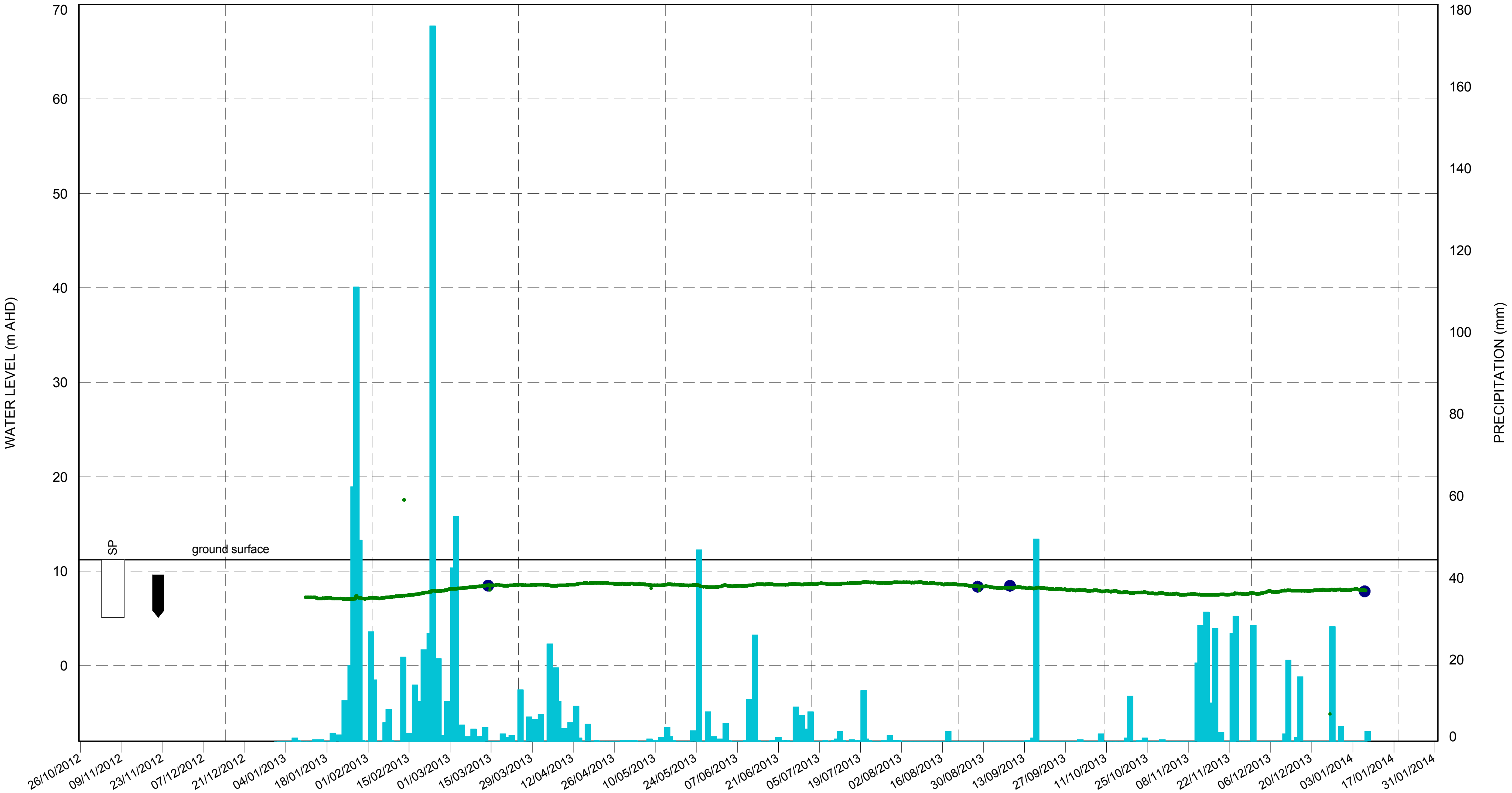
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ16**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H22** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 11.21 m AHD
Borehole Depth: 6.11 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.11 m bgl
RL of Tip: 5.10 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.11 m bgl
RL of Tip: 5.53 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

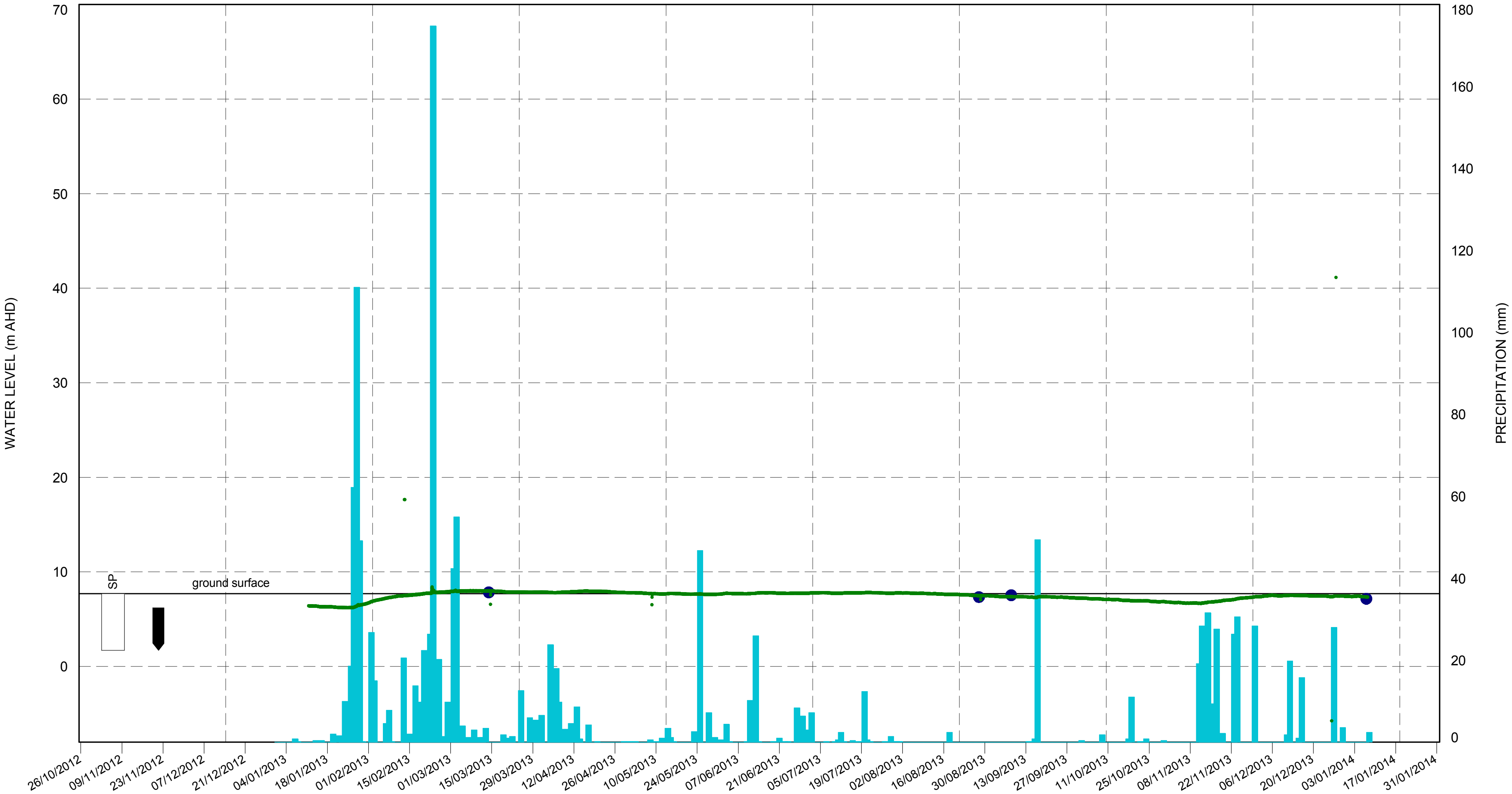
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ17**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H23** | rev:



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Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.71 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 1.71 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 2.24 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

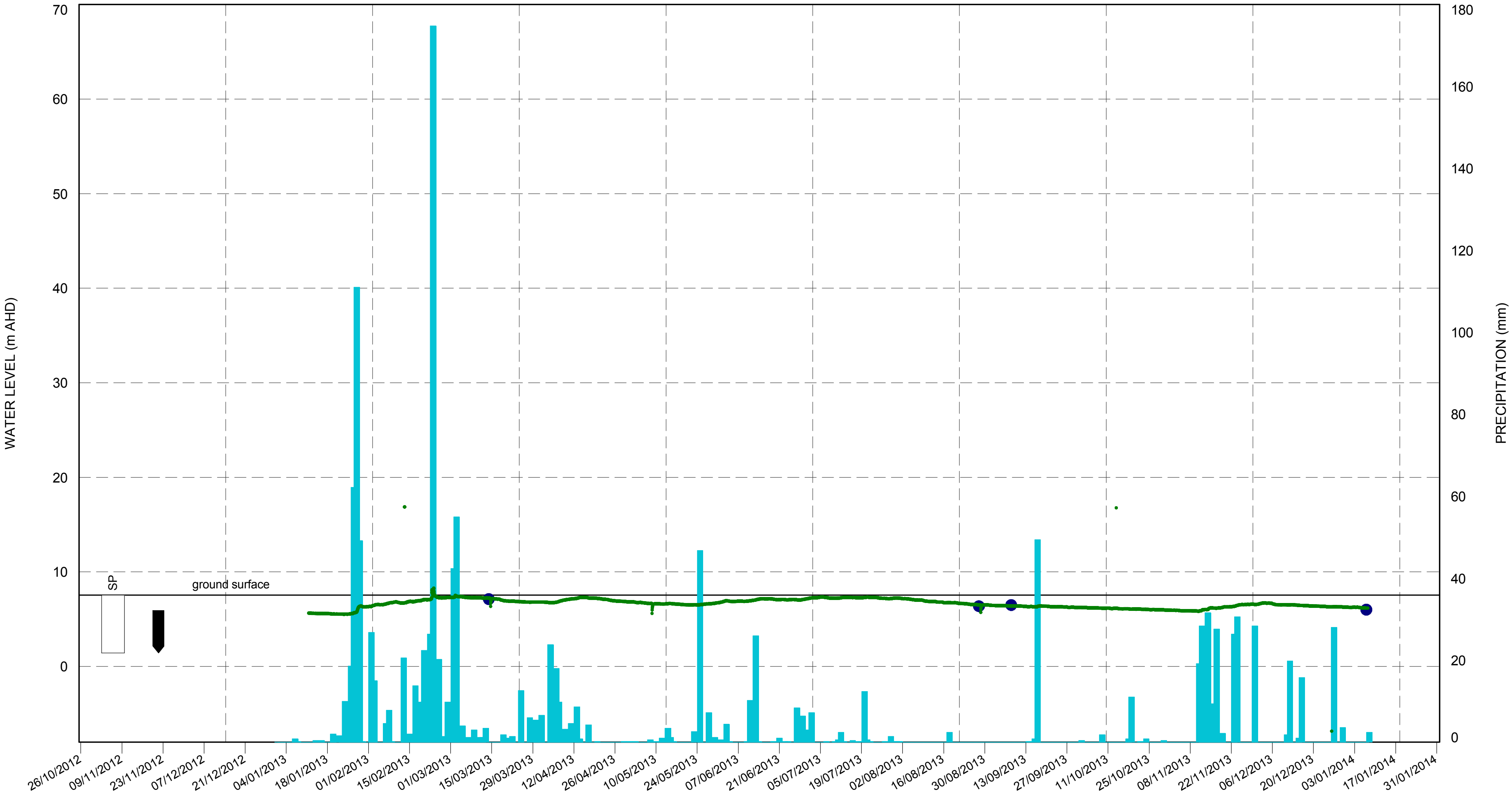
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ18**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H24** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.56 m AHD
Borehole Depth: 6.14 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.14 m bgl
RL of Tip: 1.42 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.14 m bgl
RL of Tip: 2.04 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ19**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H25** | rev:

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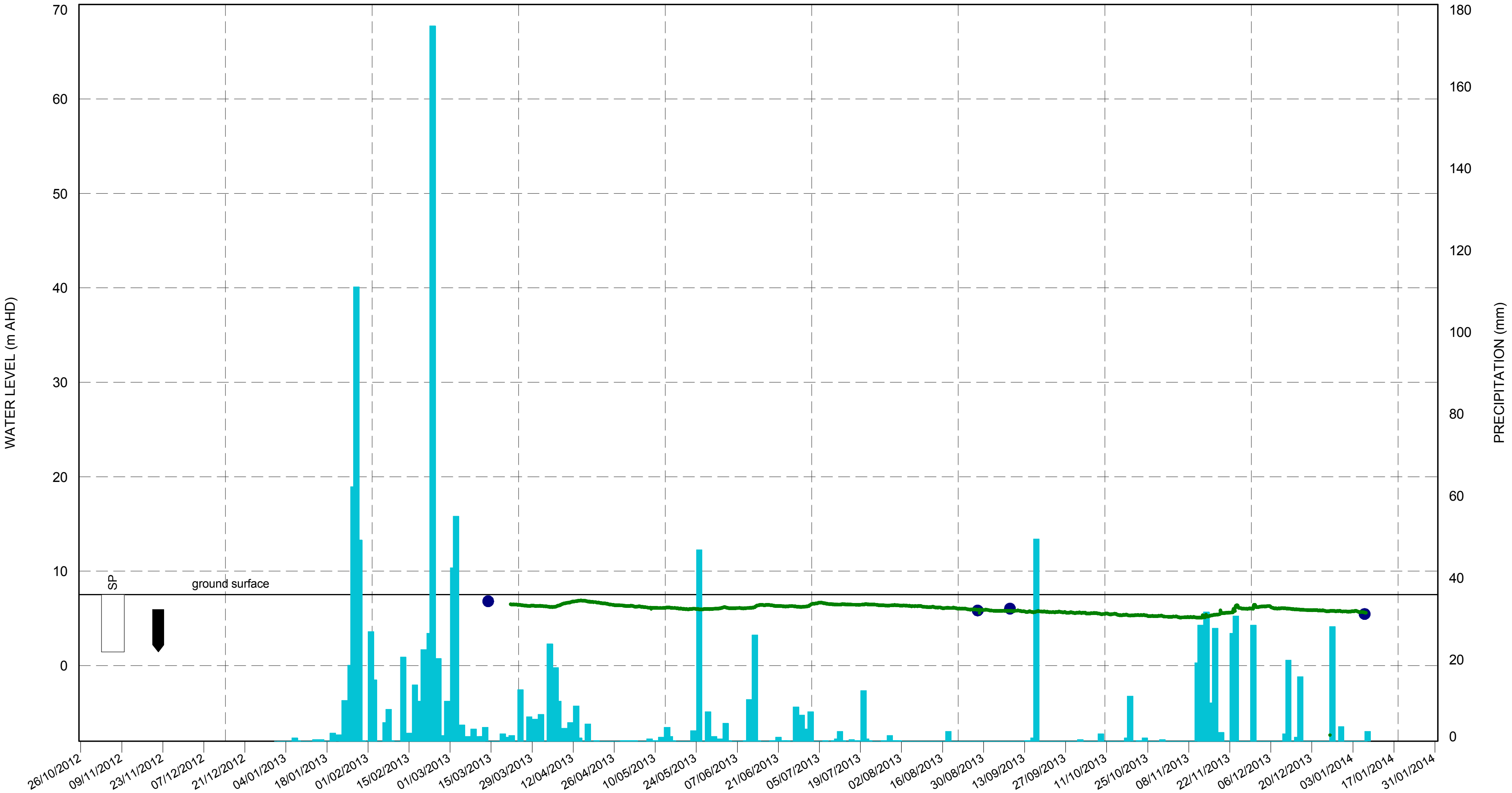


Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 7.52 m AHD
Borehole Depth: 6.06 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.06 m bgl
RL of Tip: 1.46 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.06 m bgl
RL of Tip: 1.86 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

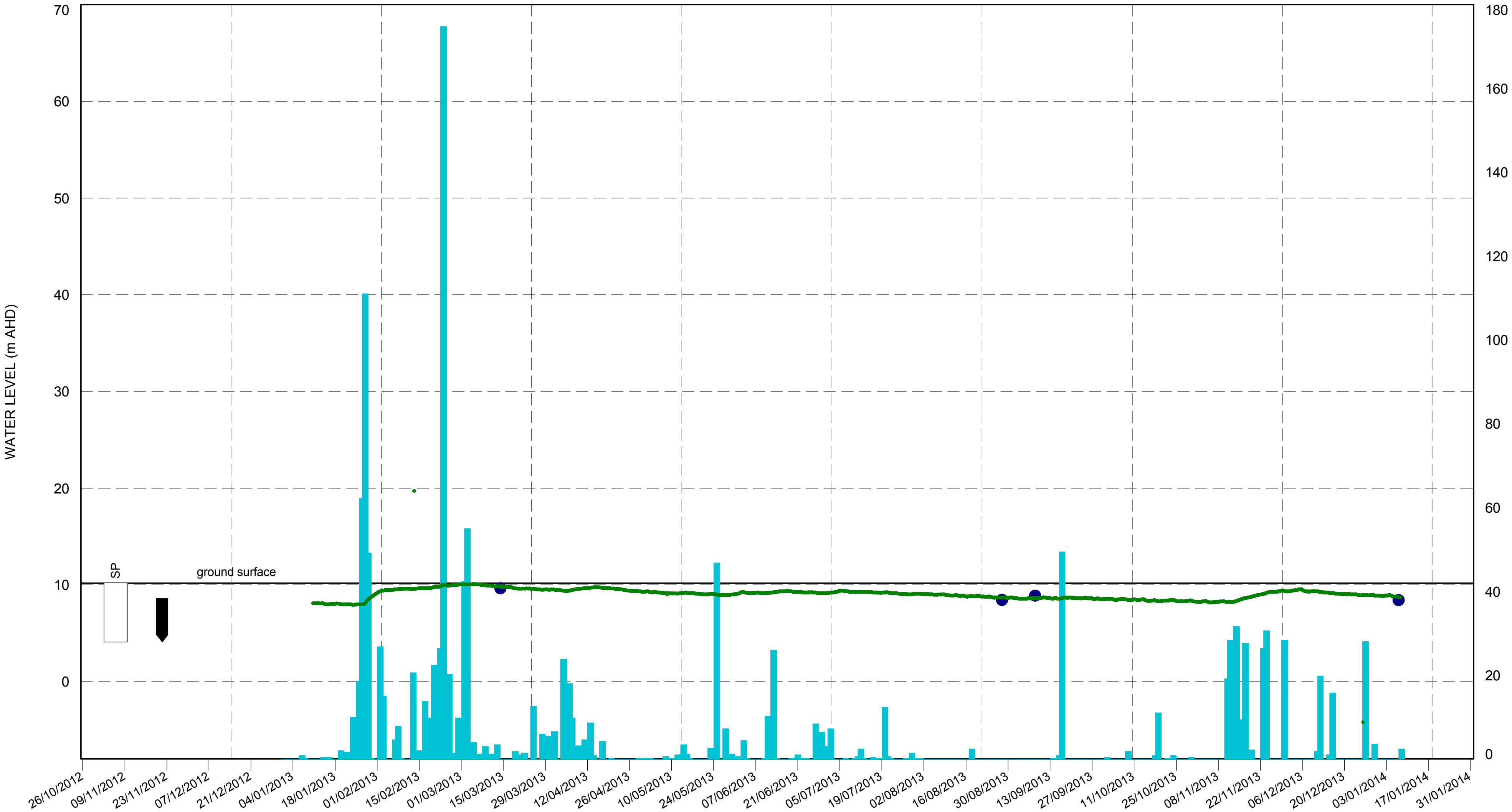
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ20**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H26** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 10.19 m AHD
Borehole Depth: 6.09 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.09 m bgl
RL of Tip: 4.10 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.09 m bgl
RL of Tip: 4.40 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

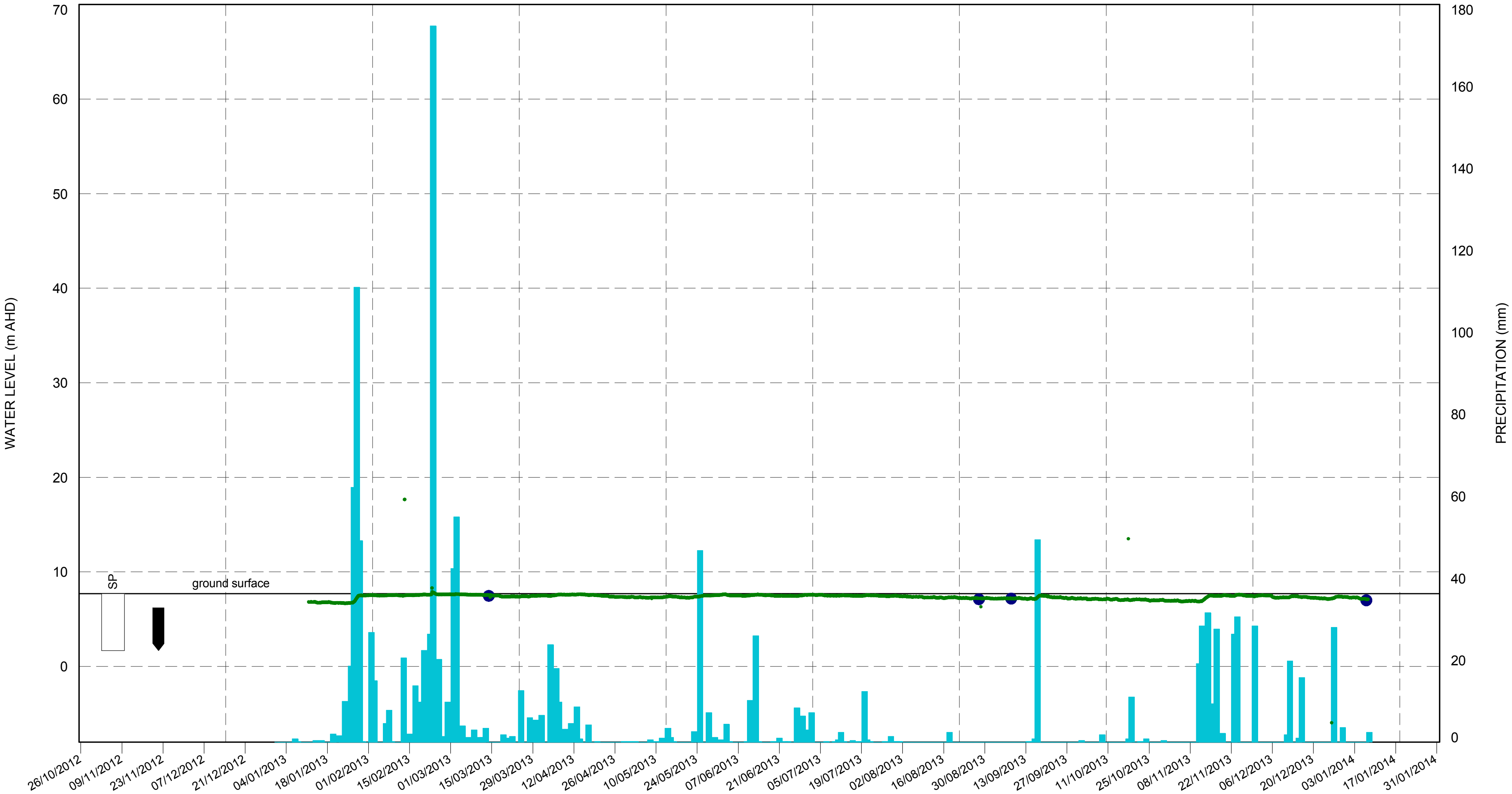
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ21**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H27** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:19



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.69 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 1.69 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 2.02 m AHD

drawn	**OH**
approved	**AB**
date	**10/03/2014**
scale	**AS SHOWN**
original size	**A4**

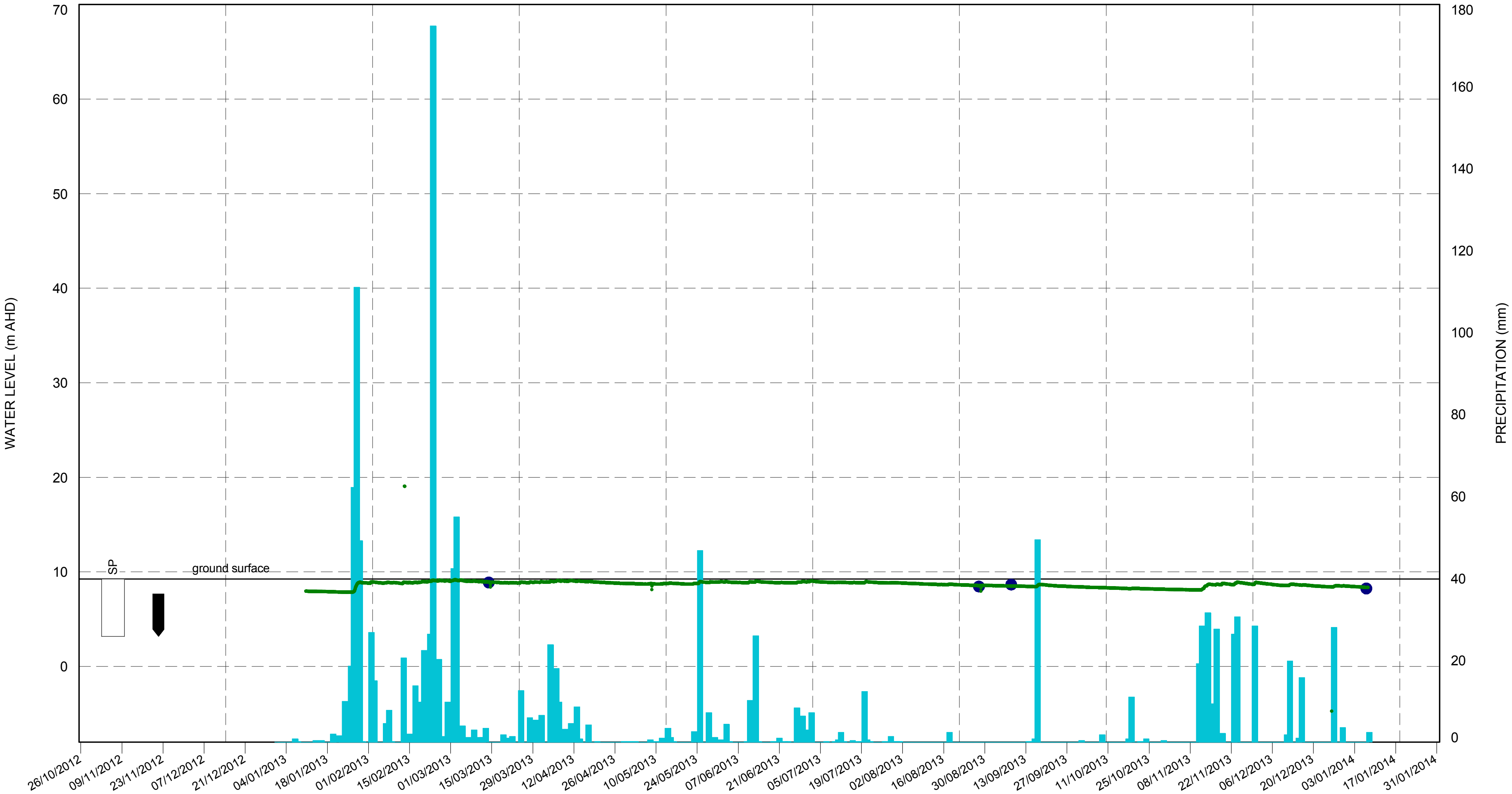
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ22**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H28** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 9.25 m AHD
Borehole Depth: 6.07 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.07 m bgl
RL of Tip: 3.18 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.07 m bgl
RL of Tip: 3.54 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

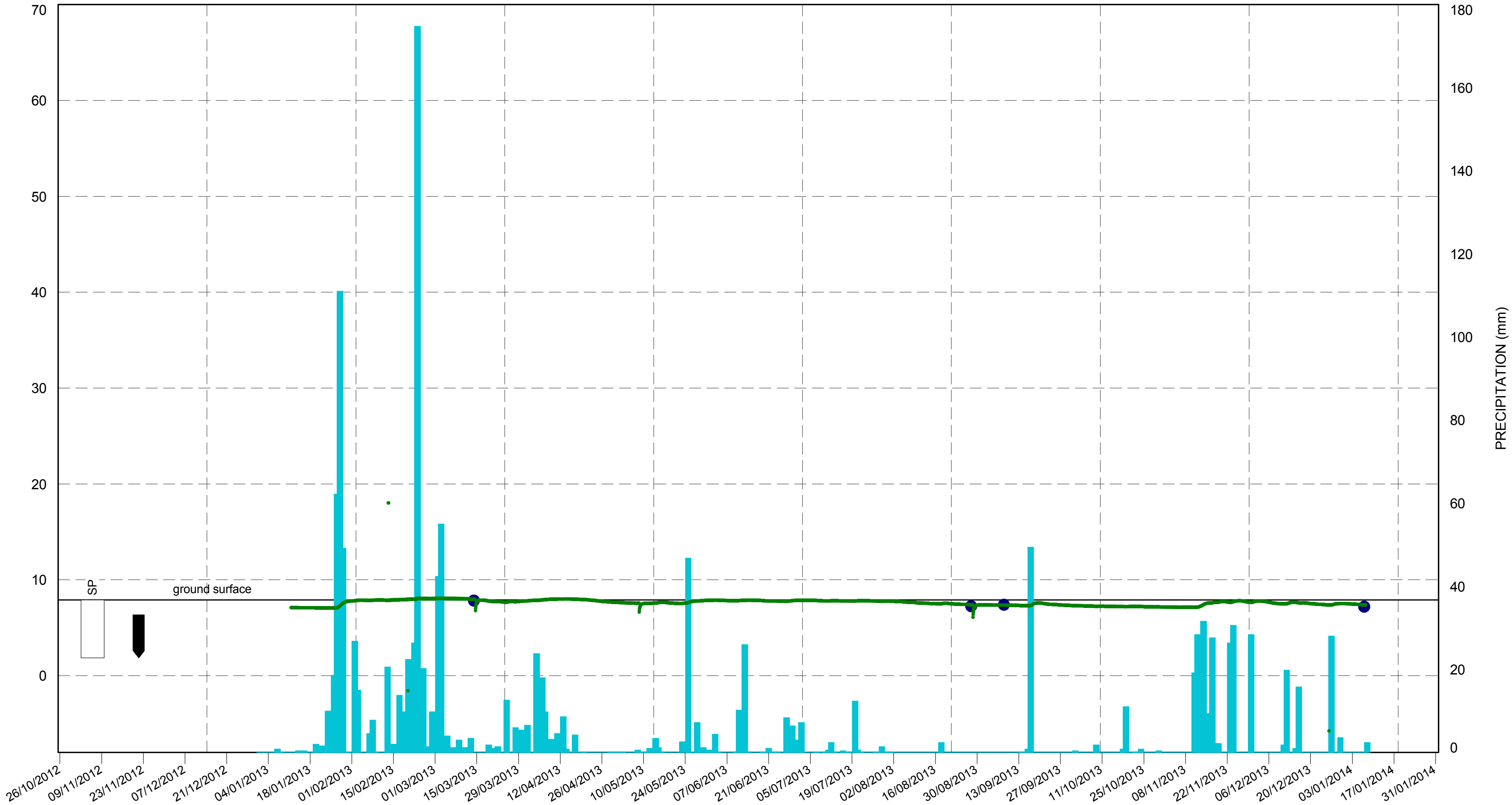
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ23**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H29** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:23

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.90 m AHD
Borehole Depth: 6.04 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.04 m bgl
RL of Tip: 1.86 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.04 m bgl
RL of Tip: 2.63 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

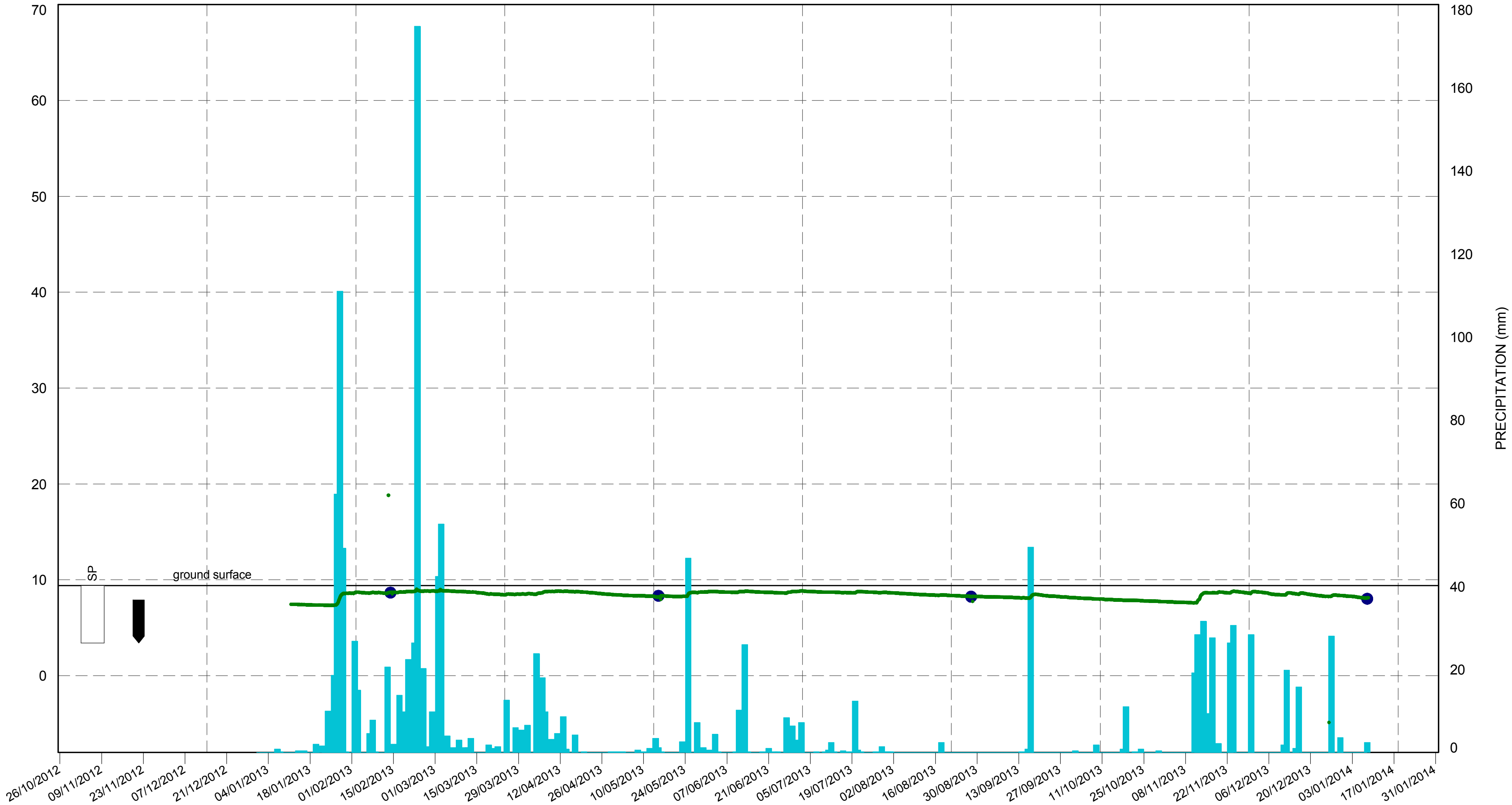
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ24**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H30** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 9.40 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 3.40 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 3.74 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

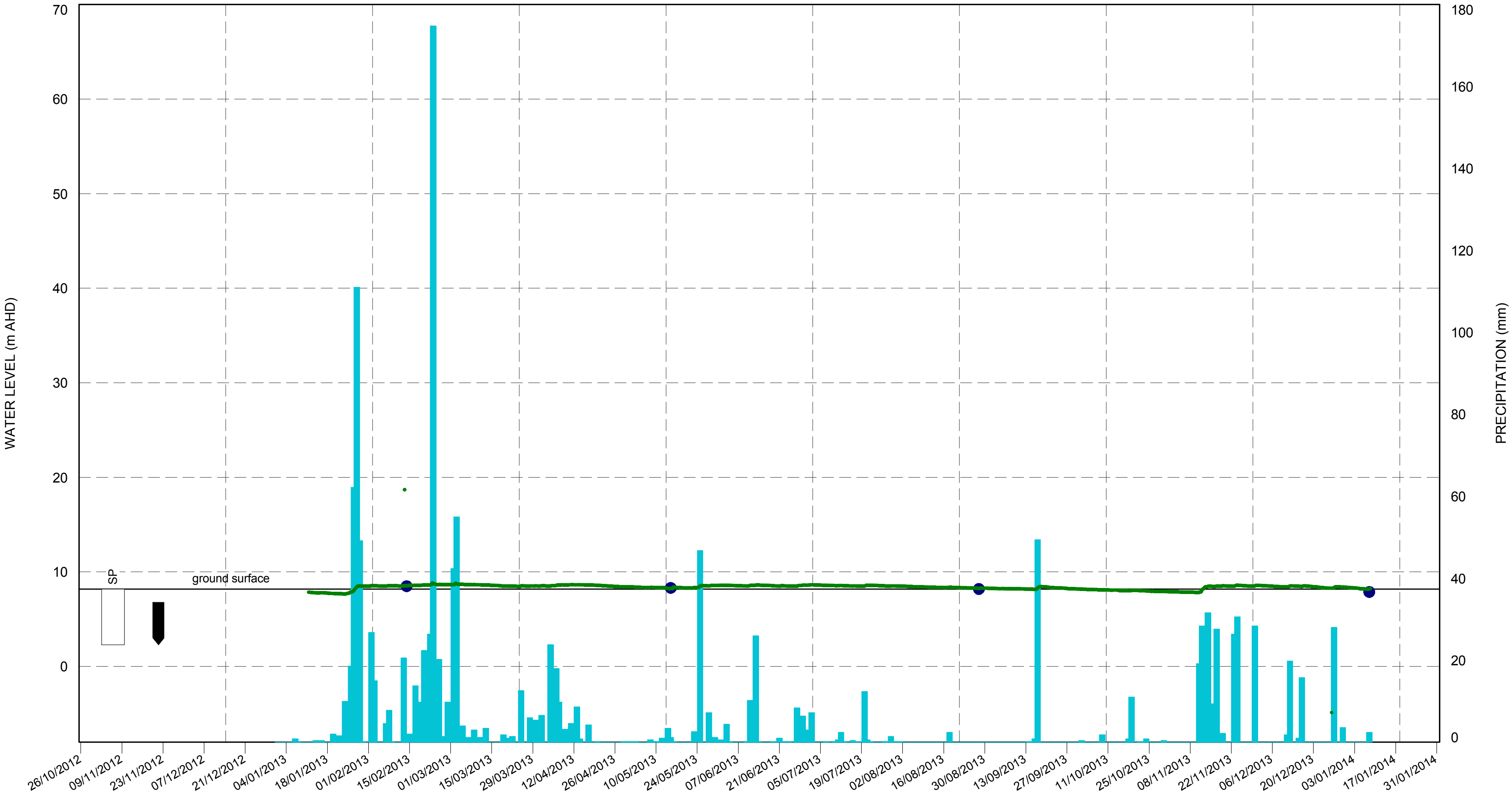
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ25**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H31** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:25



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 8.18 m AHD
Borehole Depth: 5.90 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 5.90 m bgl
RL of Tip: 2.28 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 5.90 m bgl
RL of Tip: 2.60 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

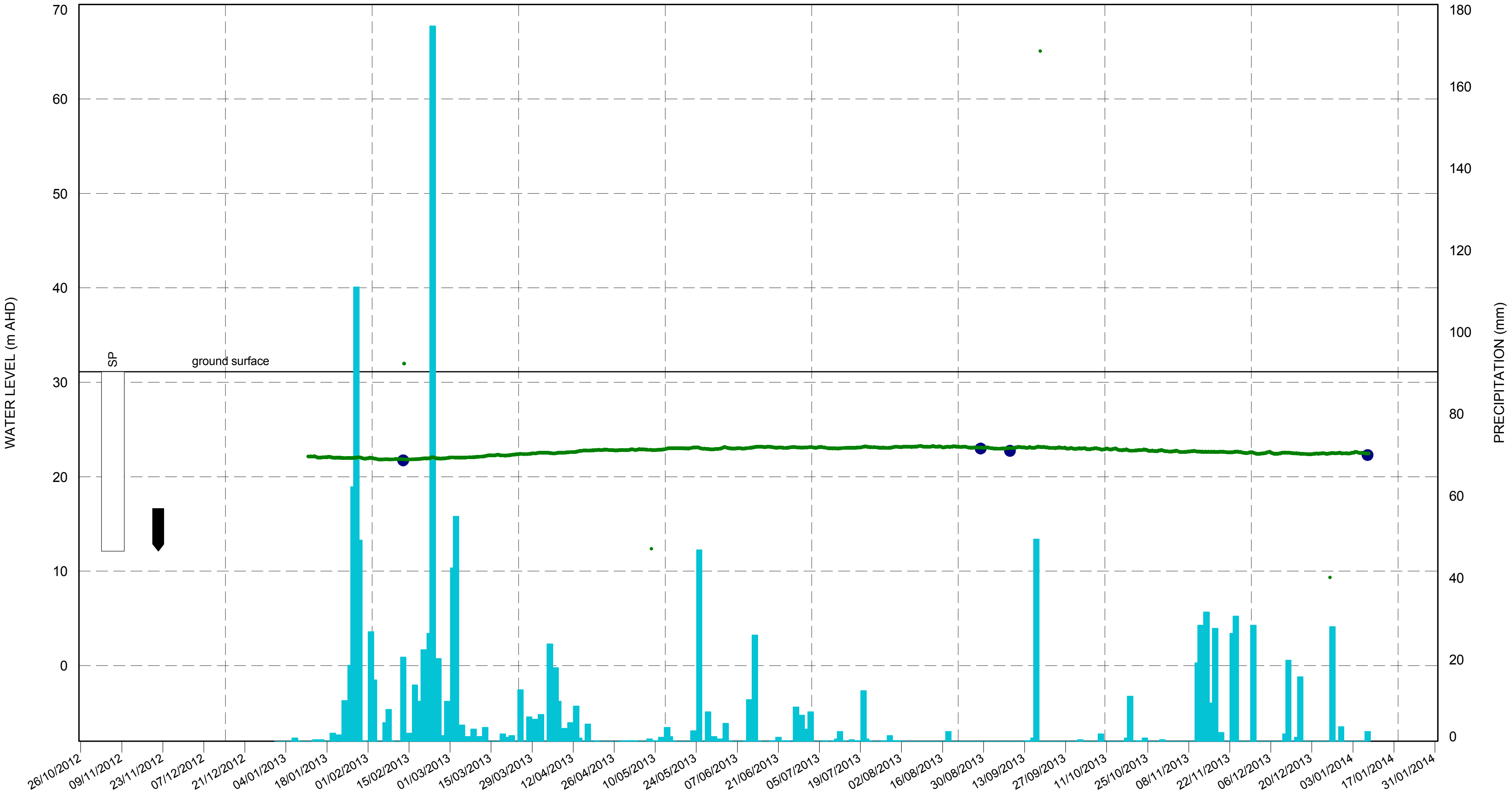
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ26**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H32** | rev:



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

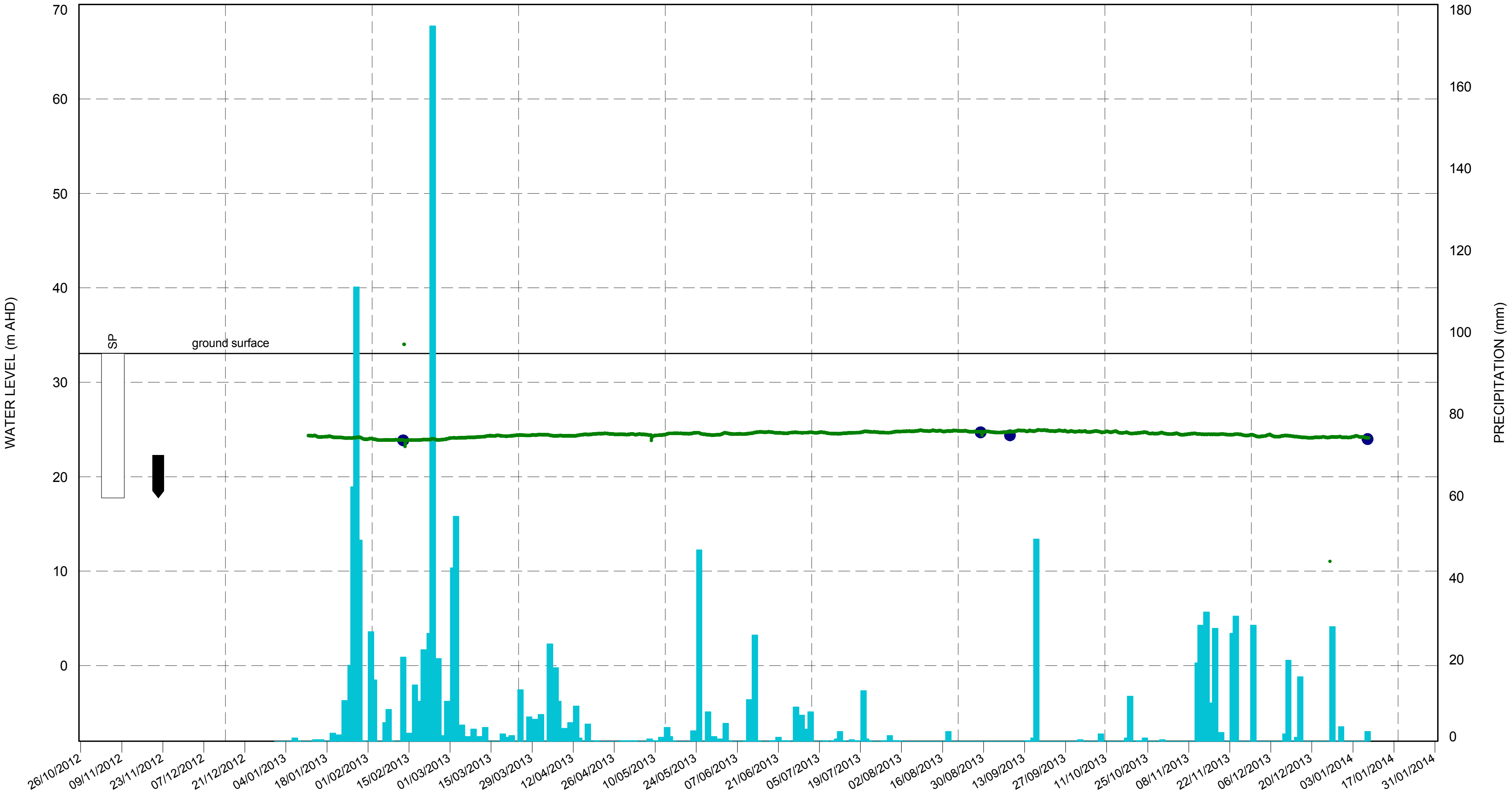
Surface RL: 31.13 m AHD
Borehole Depth: 19.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 19.00 m bgl
RL of Tip: 12.13 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 19.00 m bgl
RL of Tip: 12.37 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH	coffey	client: Roads and Maritime Services
approved	AB		project: Glenugie to Devils Pulpit Groundwater Monitoring
date	10/03/2014		title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ27**
scale	AS SHOWN		
original size	A4		project no: GEOTCOFH03059AA-AO fig no: **FIGURE H33** rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 33.04 m AHD
Borehole Depth: 15.27 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.27 m bgl
RL of Tip: 17.77 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.27 m bgl
RL of Tip: 18.70 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

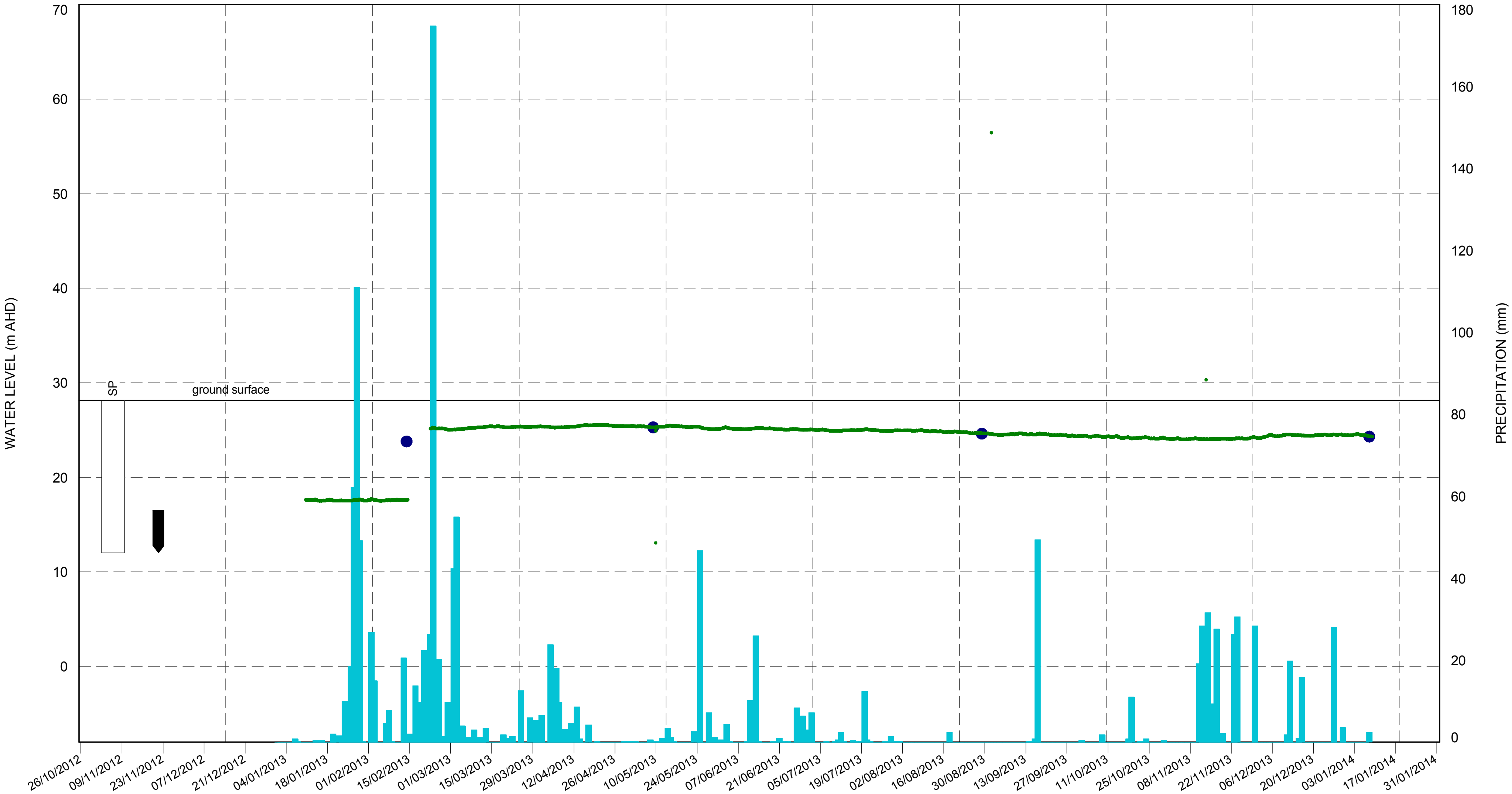
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ28**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H34** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 28.12 m AHD
Borehole Depth: 16.10 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 16.10 m bgl
RL of Tip: 12.02 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 16.10 m bgl
RL of Tip: 13.02 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

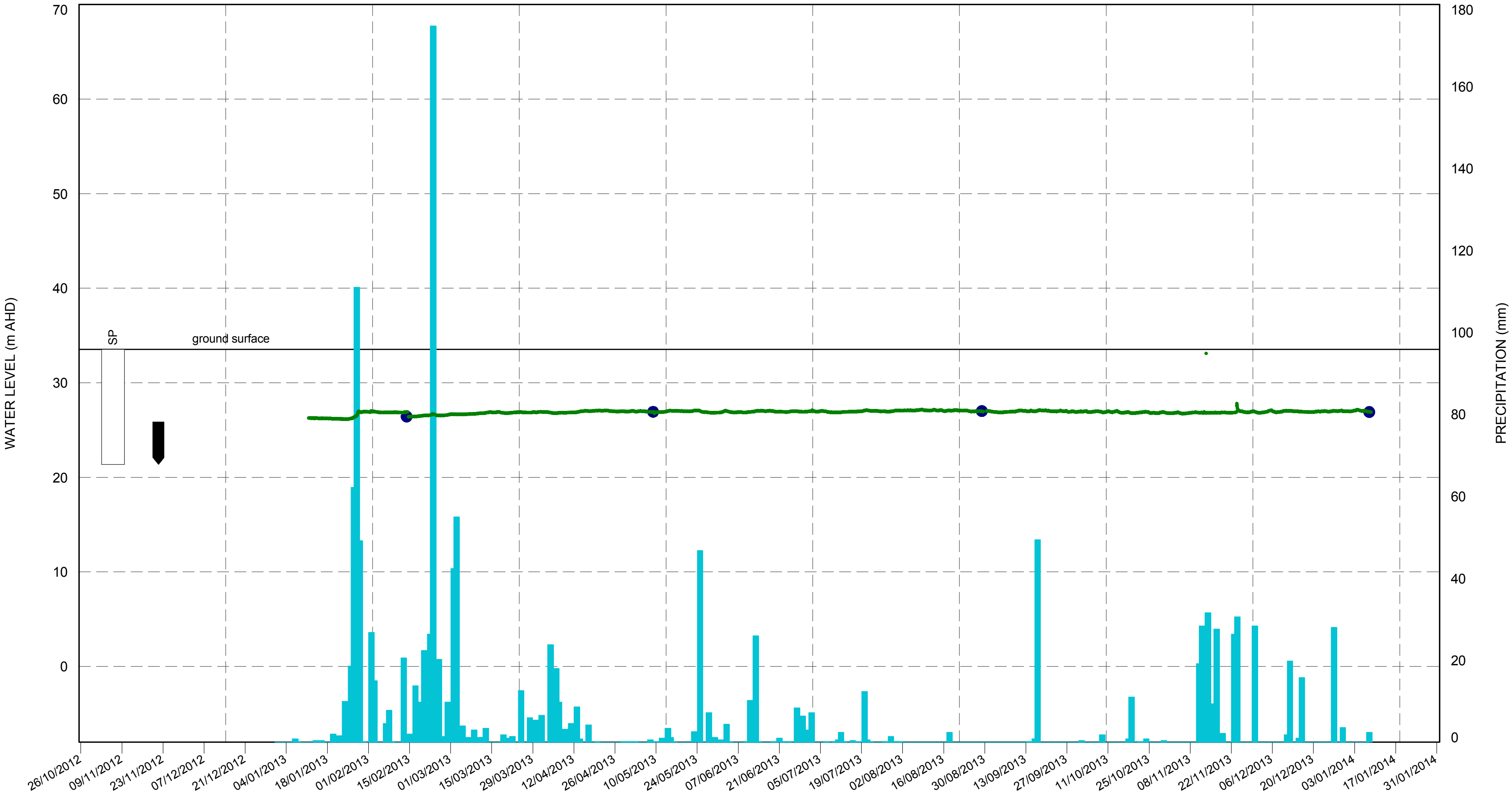
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ29**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H35** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 33.54 m AHD
Borehole Depth: 12.18 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 12.18 m bgl
RL of Tip: 21.36 m AHD

━: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 12.18 m bgl
RL of Tip: 21.78 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

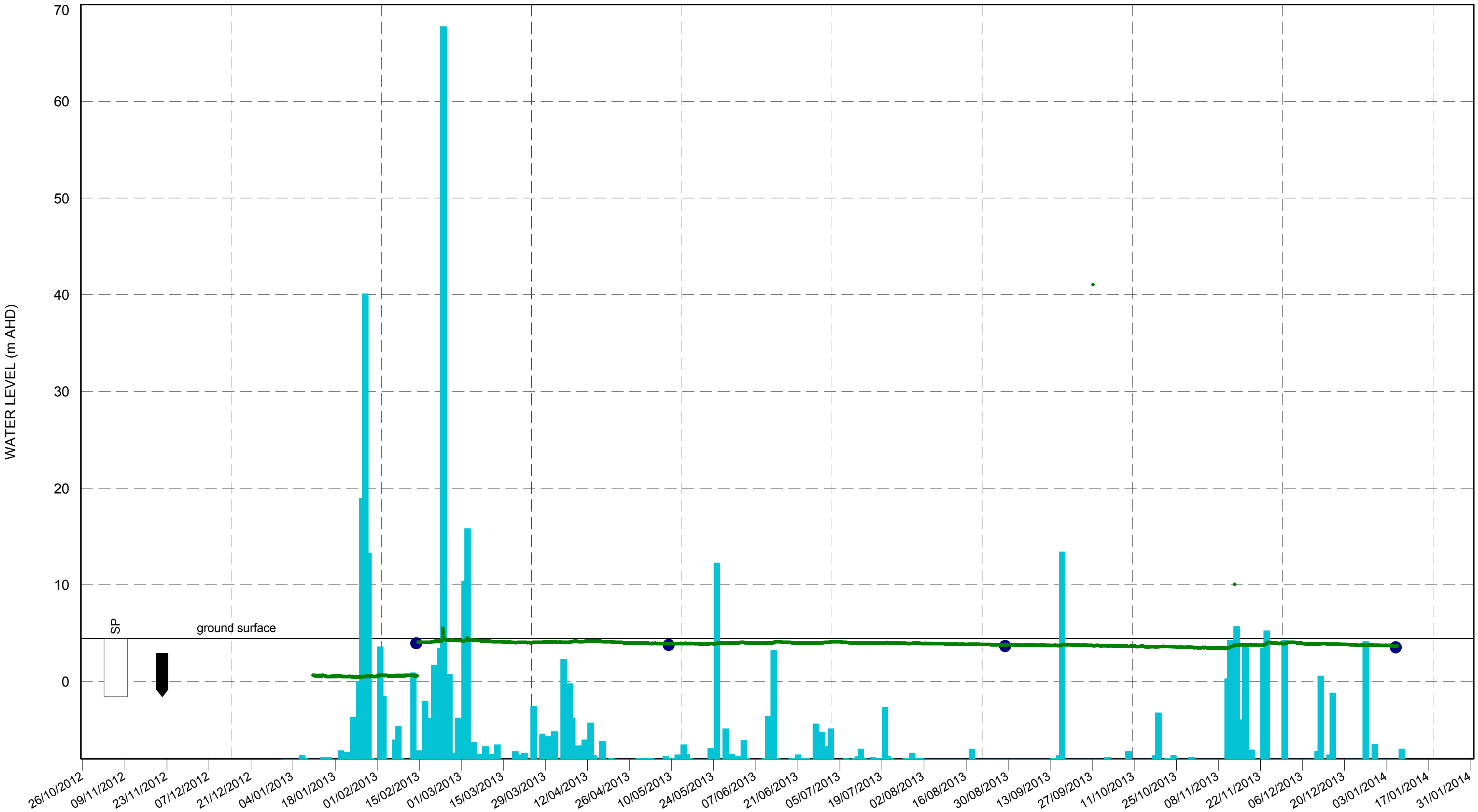
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ30**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H36** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:30



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 4.44 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -1.56 m AHD

━ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -1.07 m AHD

■ : Rainfall data is from
Bureau of Meteorology
website (www.bom.gov.au)
Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

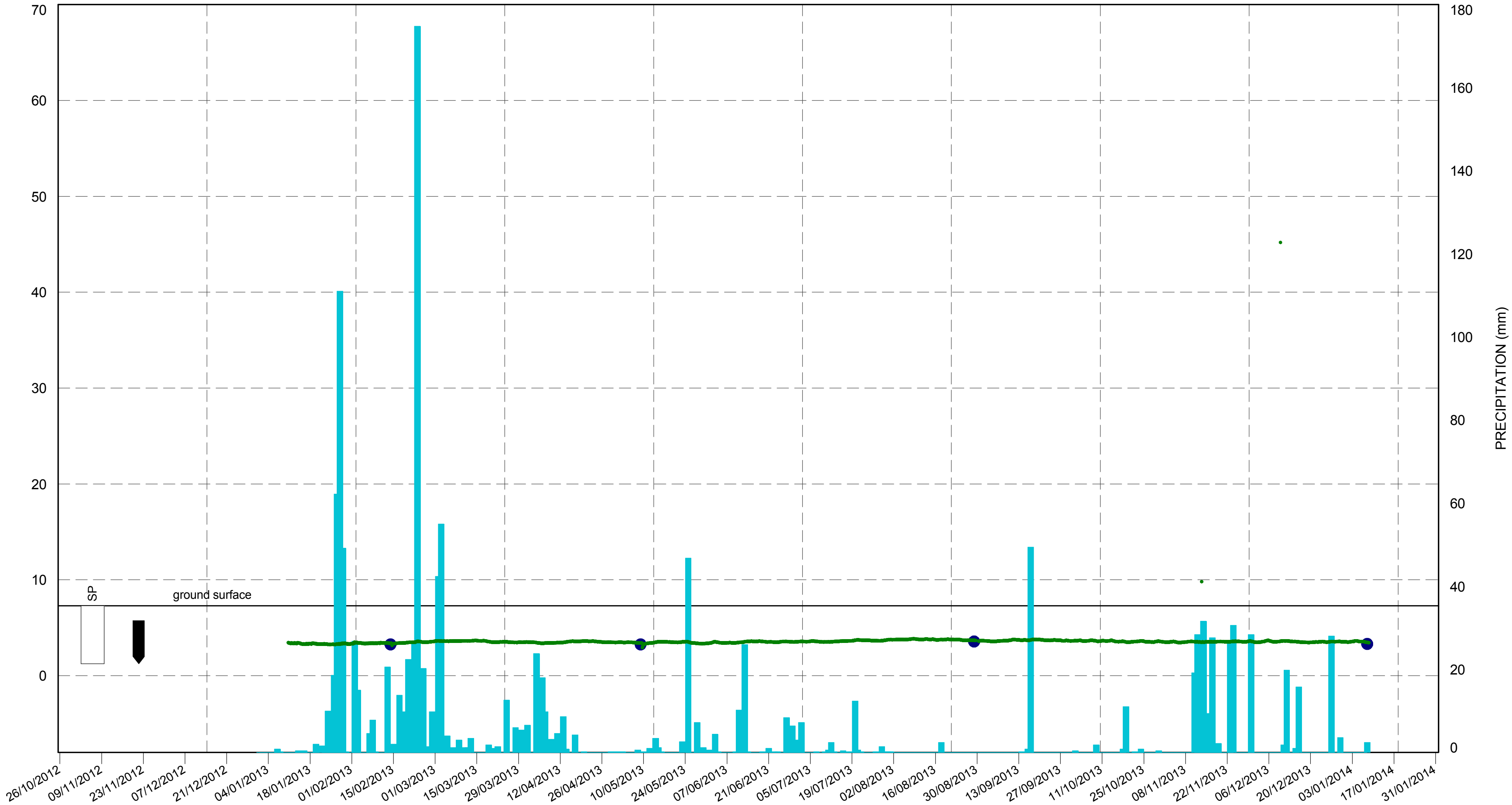
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME**
PZ31

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H37** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:32



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:33

Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.30 m AHD
Borehole Depth: 6.05 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.05 m bgl
RL of Tip: 1.34 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.05 m bgl
RL of Tip: 1.71 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

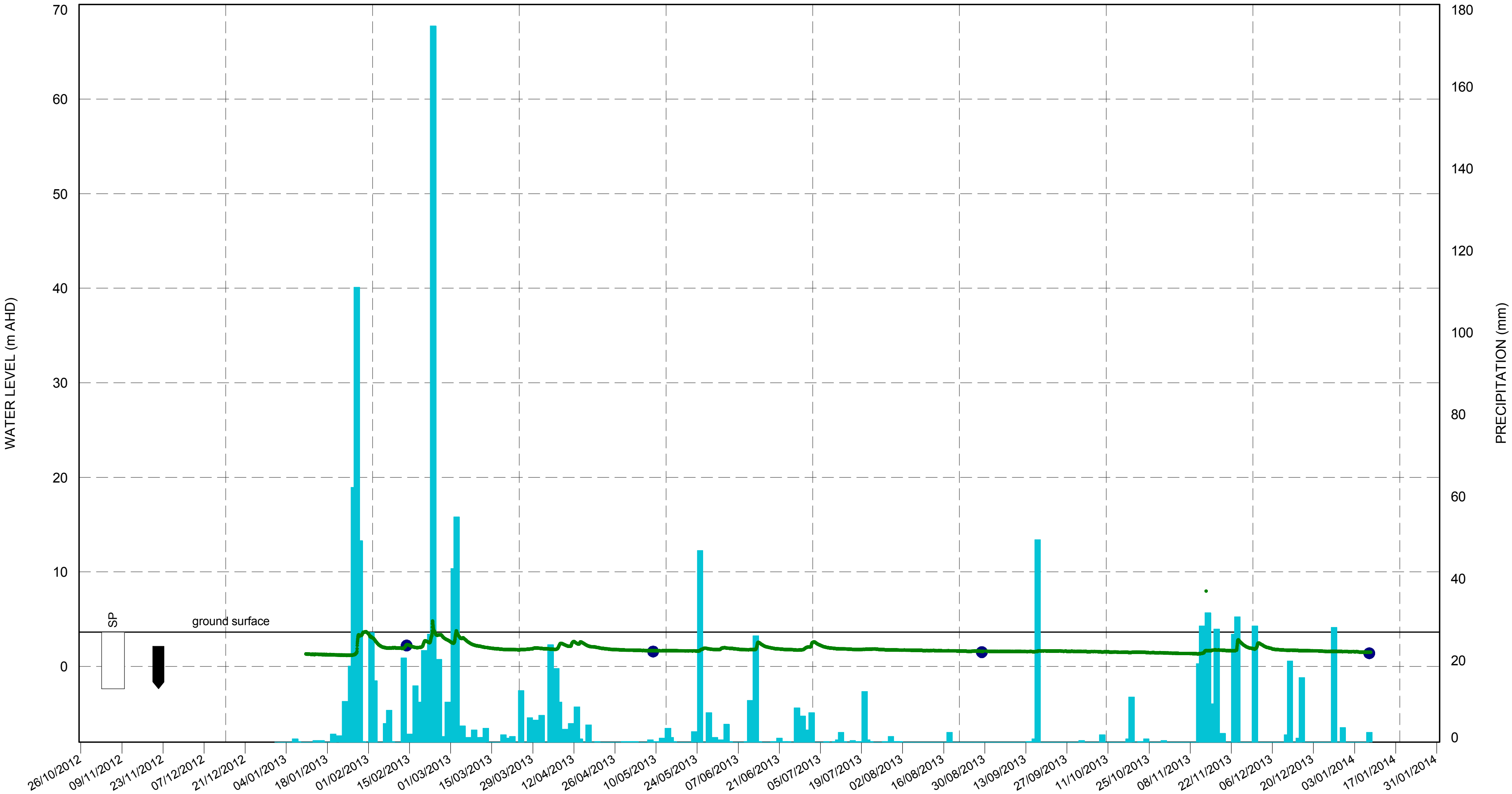
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ32**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H38** | rev:



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 3.64 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.36 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.16 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

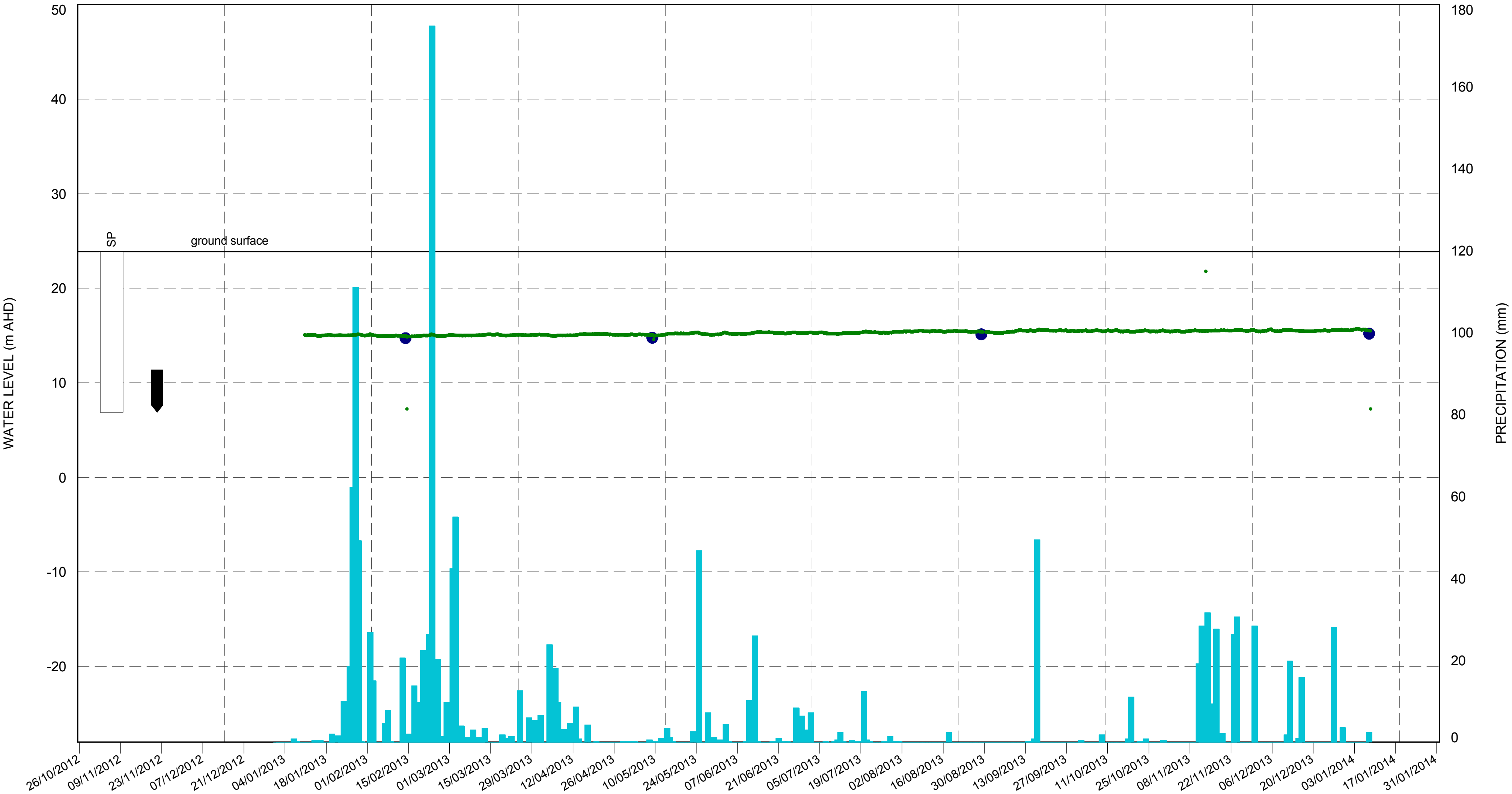
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ34**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H39** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 23.88 m AHD
Borehole Depth: 17.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 17.00 m bgl
RL of Tip: 6.88 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 17.00 m bgl
RL of Tip: 7.21 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

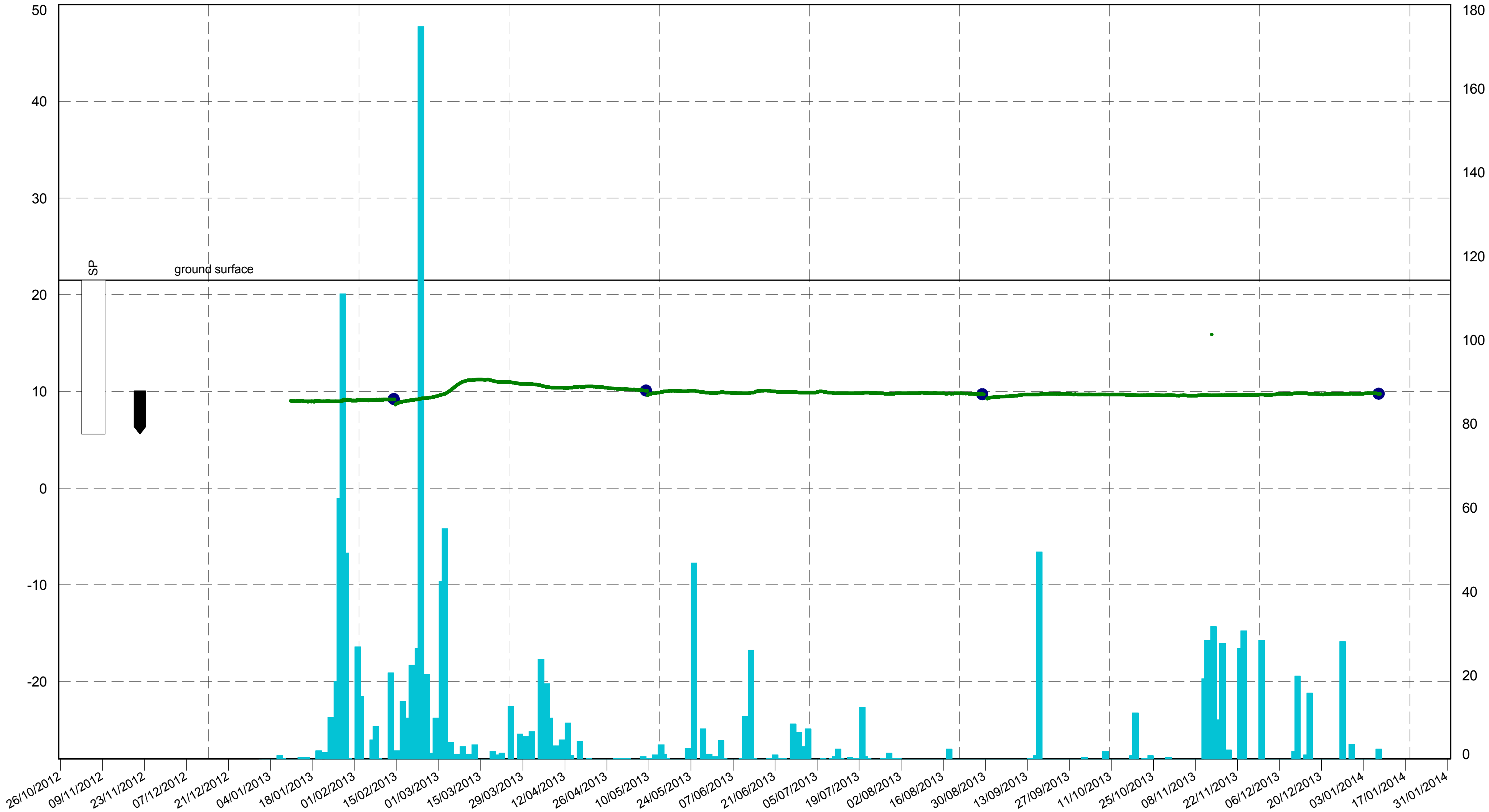
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ35**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H40** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:42

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 21.51 m AHD
Borehole Depth: 15.92 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.92 m bgl
RL of Tip: 5.59 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.92 m bgl
RL of Tip: 5.51 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

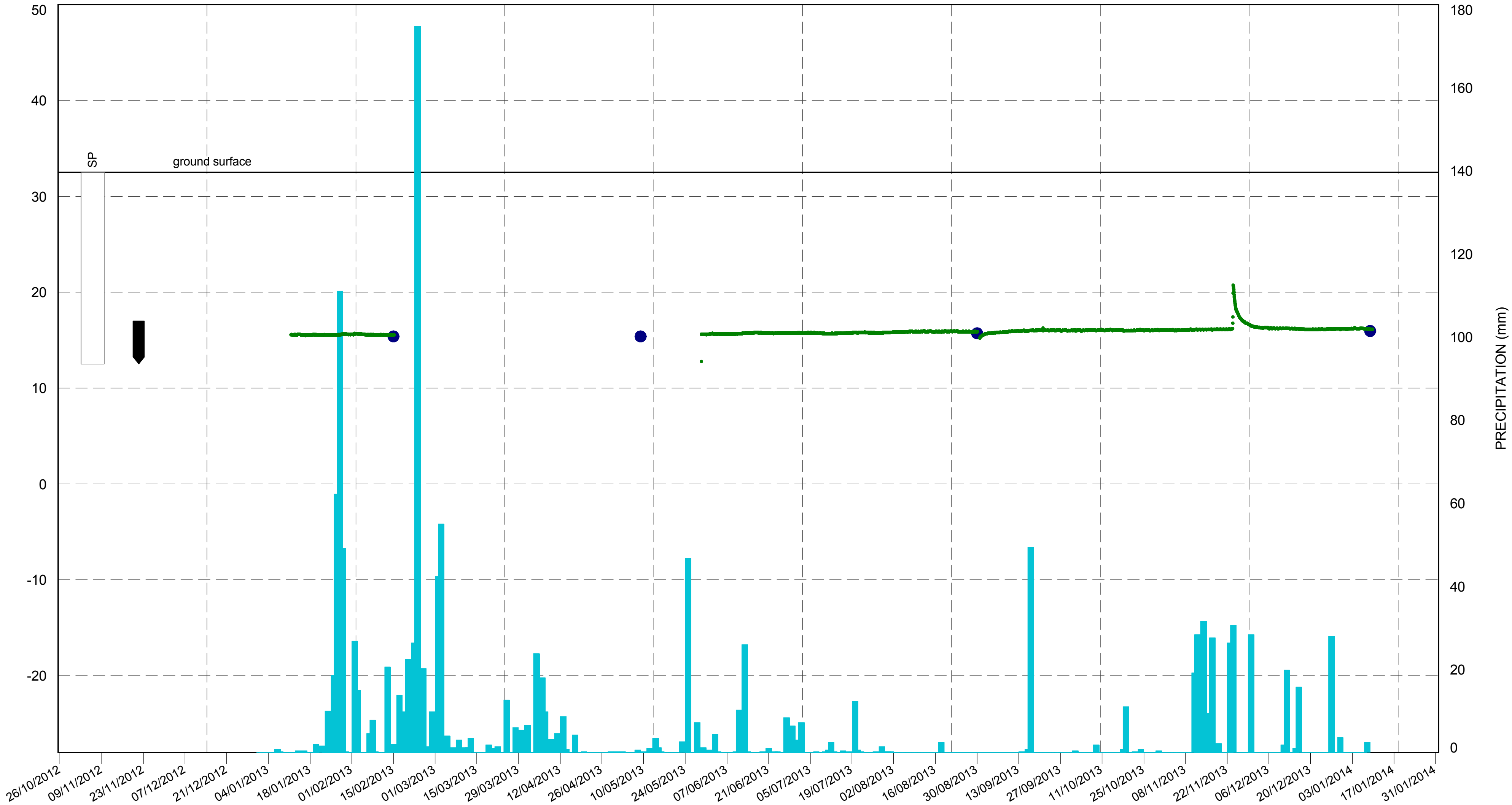
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ36**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H41** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 32.51 m AHD
Borehole Depth: 20.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 20.00 m bgl
RL of Tip: 12.51 m AHD

—: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 20.00 m bgl
RL of Tip: 12.75 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

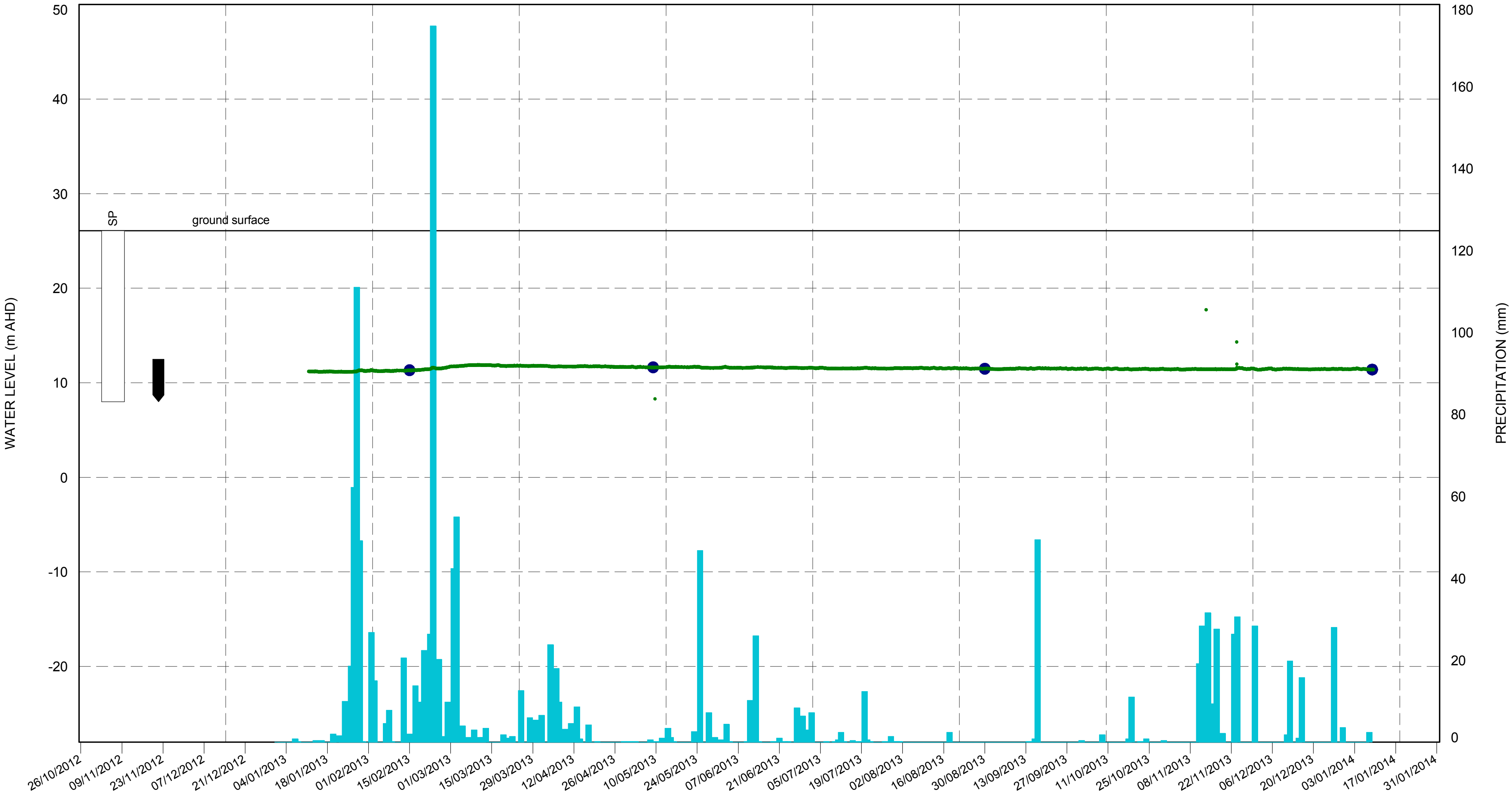
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ37**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H42** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:45

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 26.09 m AHD
Borehole Depth: 18.10 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 18.10 m bgl
RL of Tip: 7.99 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 18.10 m bgl
RL of Tip: 8.29 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

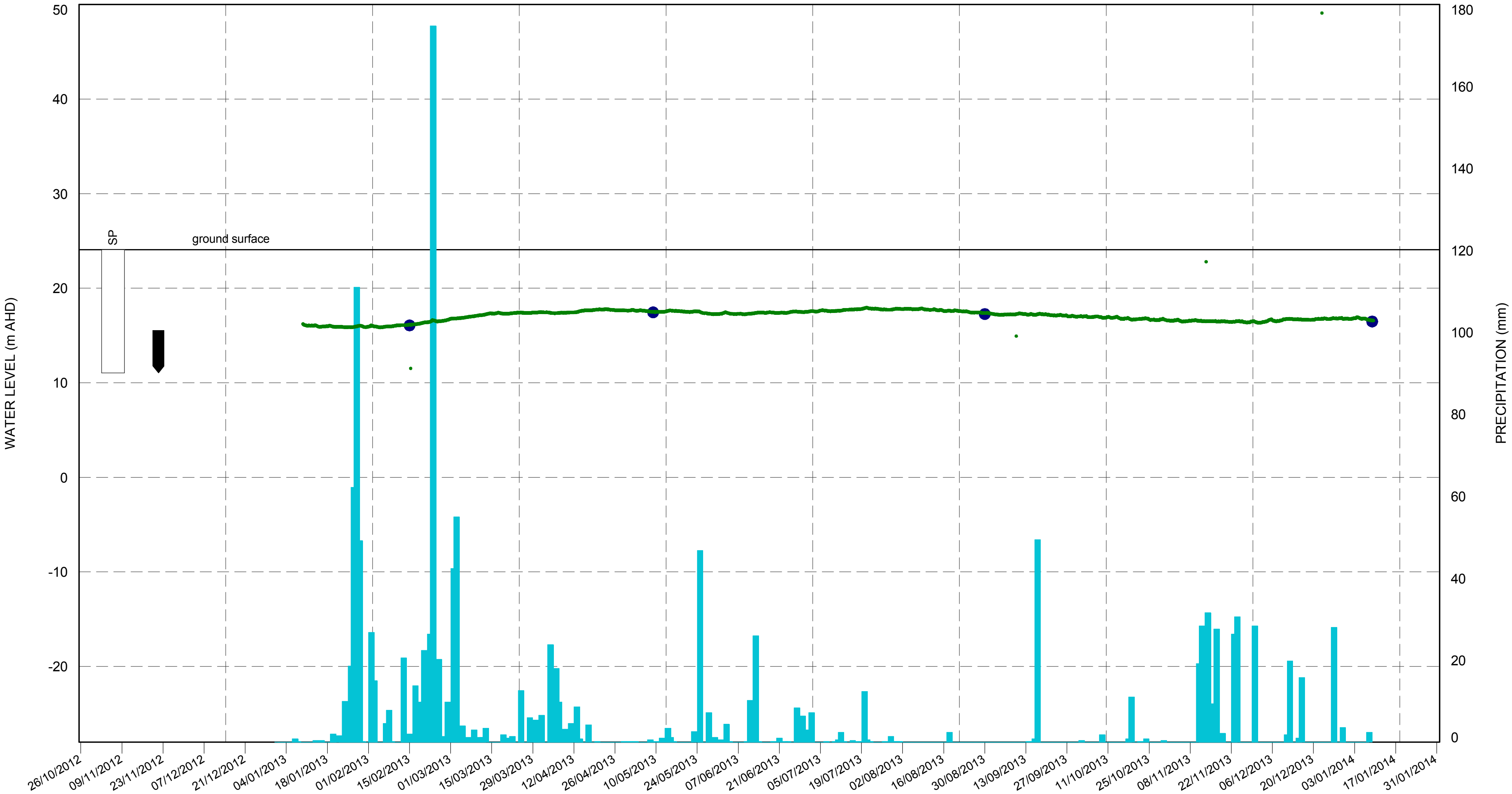
project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ38**

project no: GEOTCOFH03059AA-AO

fig no: **FIGURE H43**

rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 24.08 m AHD
Borehole Depth: 13.05 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 13.05 m bgl
RL of Tip: 11.03 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 13.05 m bgl
RL of Tip: 11.50 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

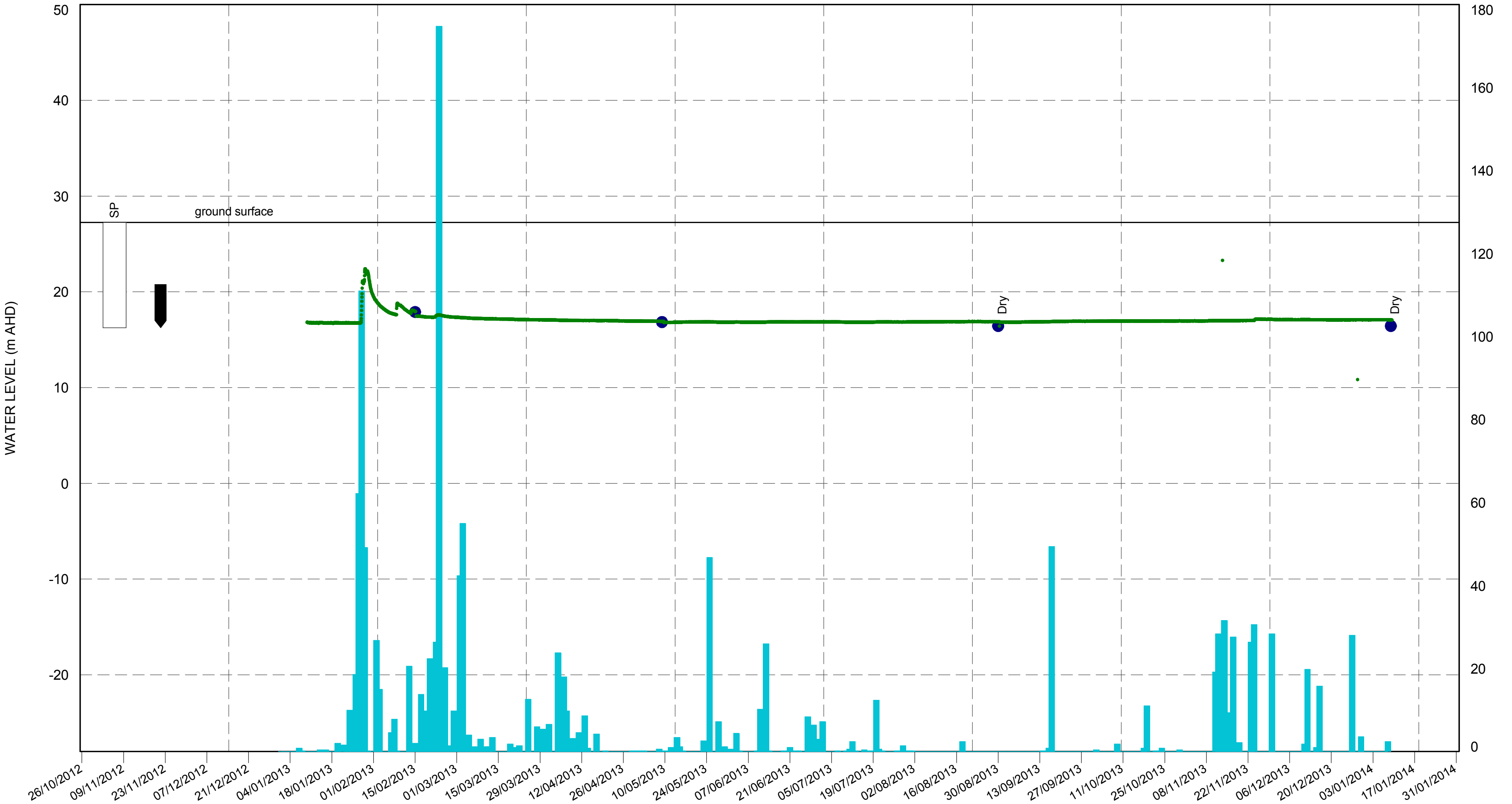
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME
PZ39

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H44 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:46



Bentonite	Gravel
Concrete	Grout
Cuttings	Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 27.26 m AHD
Borehole Depth: 11.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 11.00 m bgl
RL of Tip: 16.26 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 11.00 m bgl
RL of Tip: 16.44 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

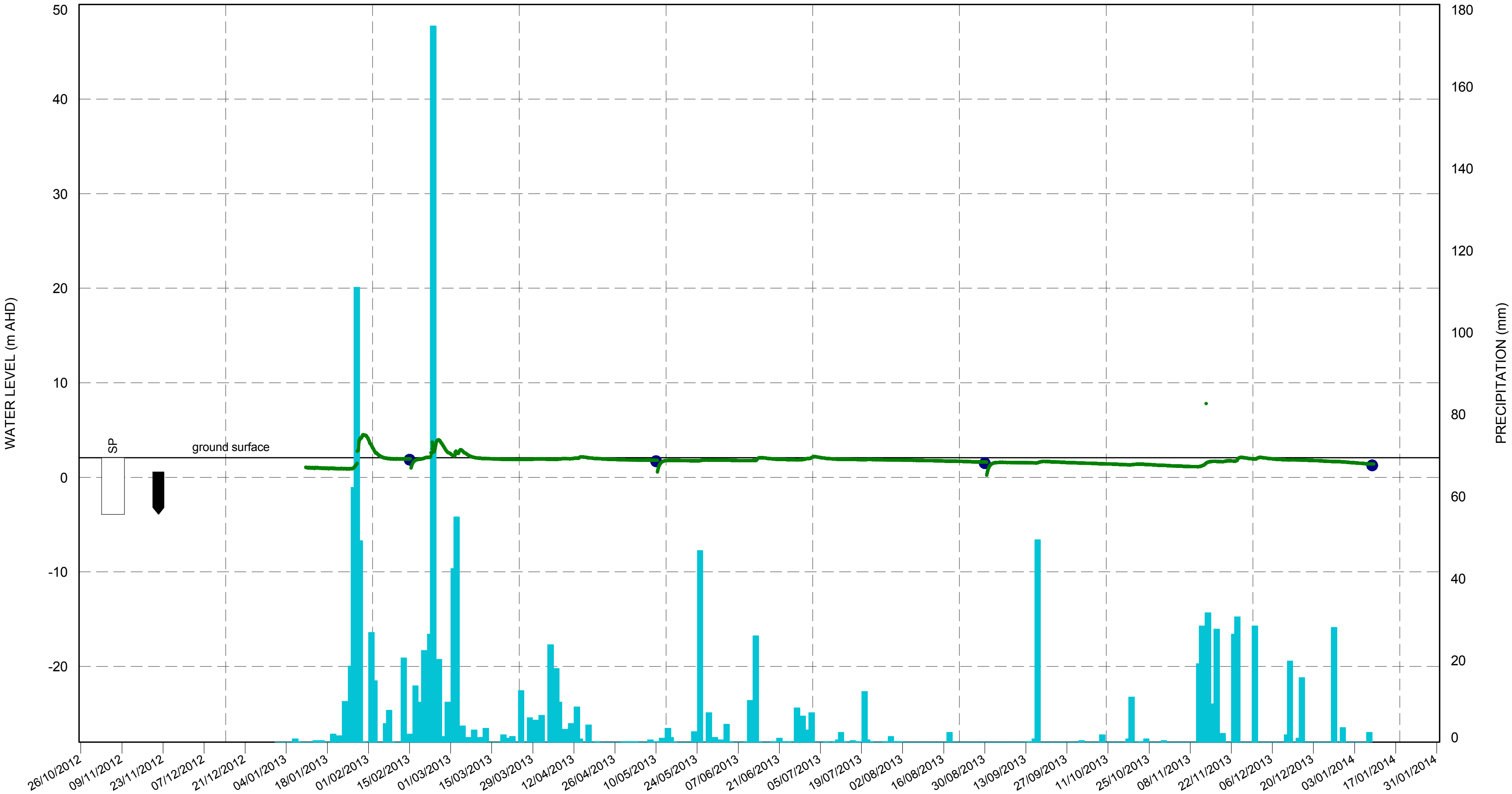
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ40**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H45** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:47



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 2.07 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.93 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.60 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

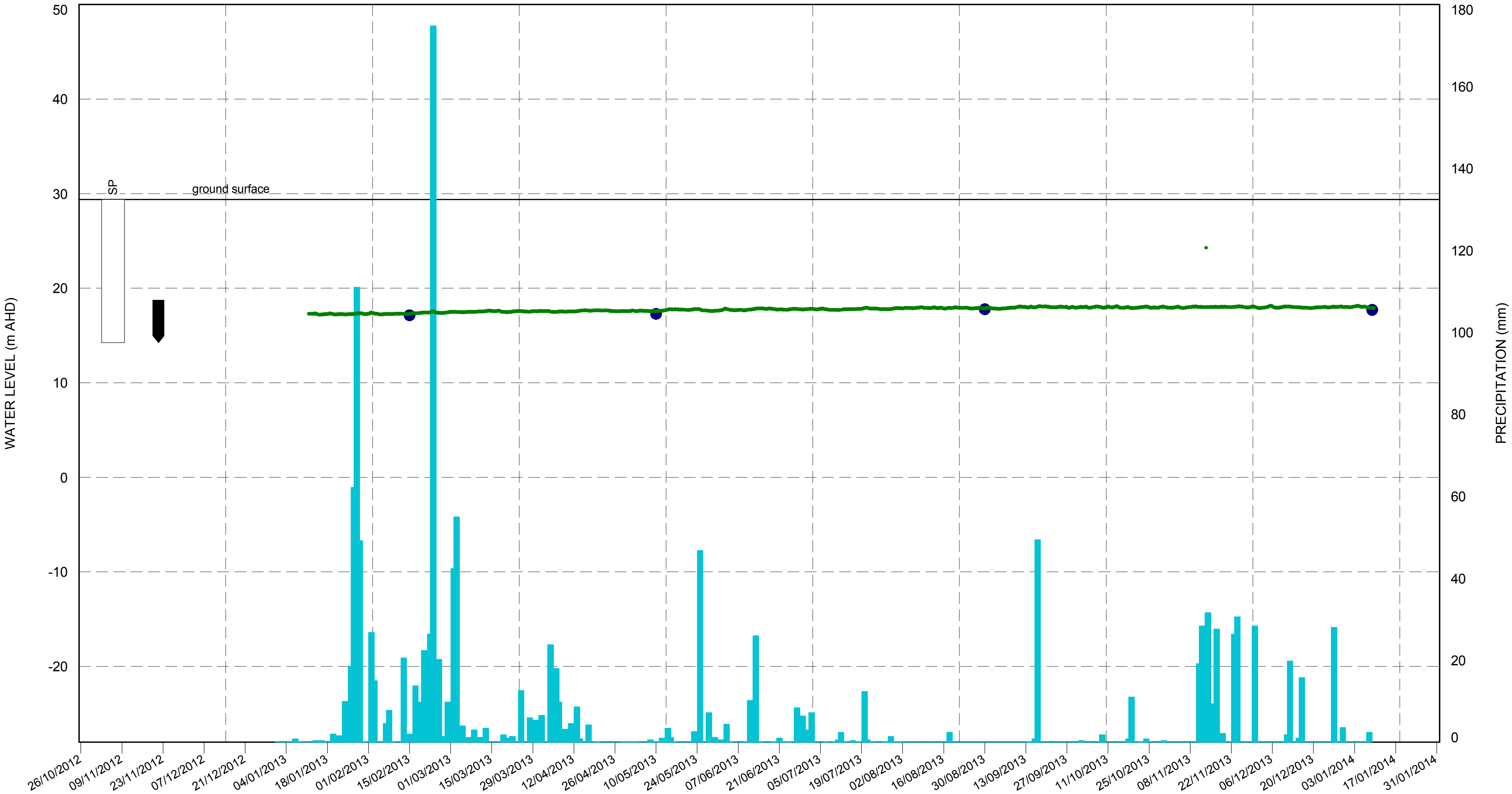
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ41**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H46** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:49

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 29.39 m AHD
Borehole Depth: 15.15 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.15 m bgl
RL of Tip: 14.24 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.15 m bgl
RL of Tip: 14.53 m AHD

■ : Rainfall data is from
Bureau of Meteorology
website (www.bom.gov.au)
Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

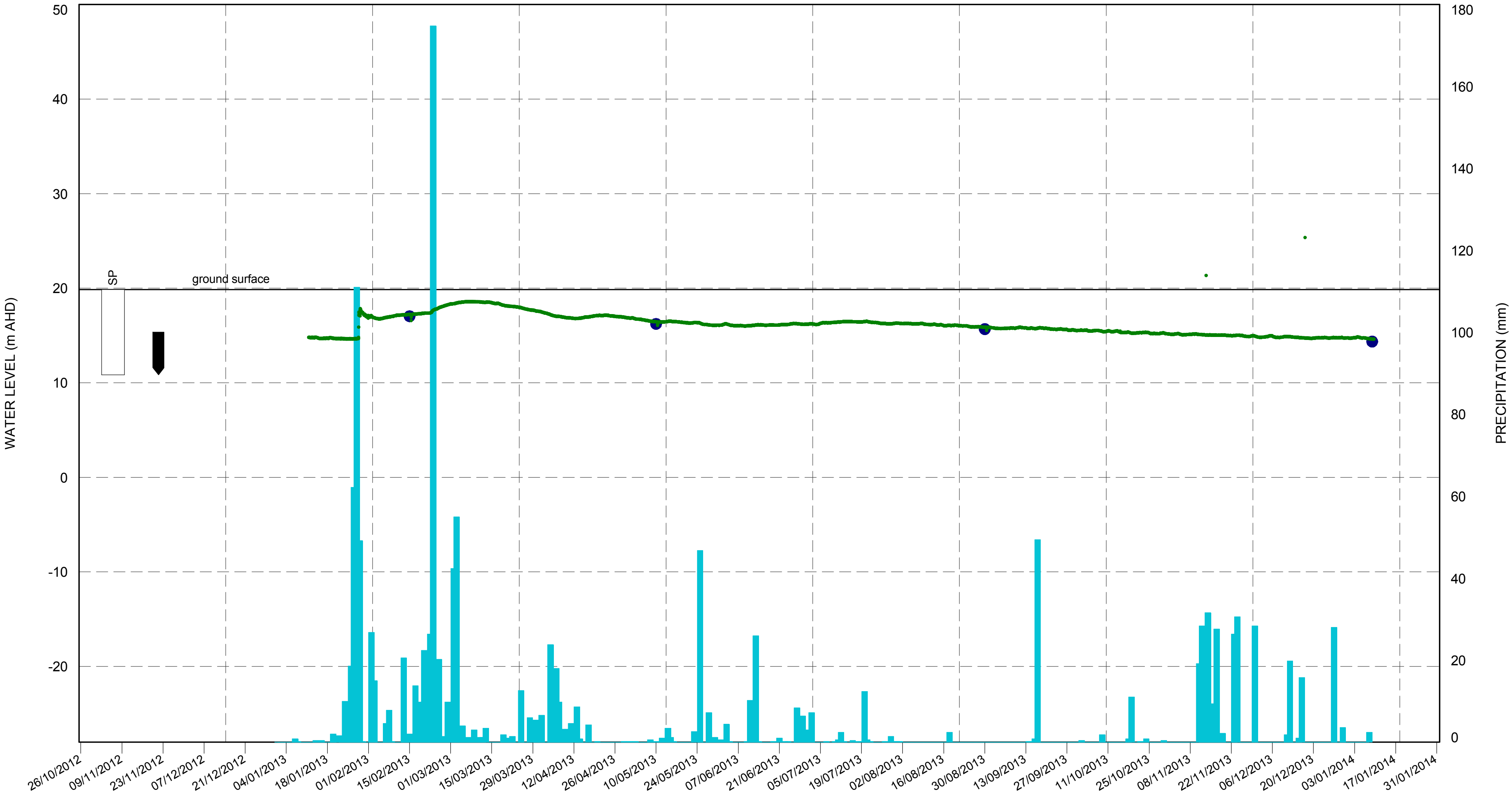
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ43**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H47** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 19.85 m AHD
Borehole Depth: 9.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 9.00 m bgl
RL of Tip: 10.85 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 9.00 m bgl
RL of Tip: 11.21 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

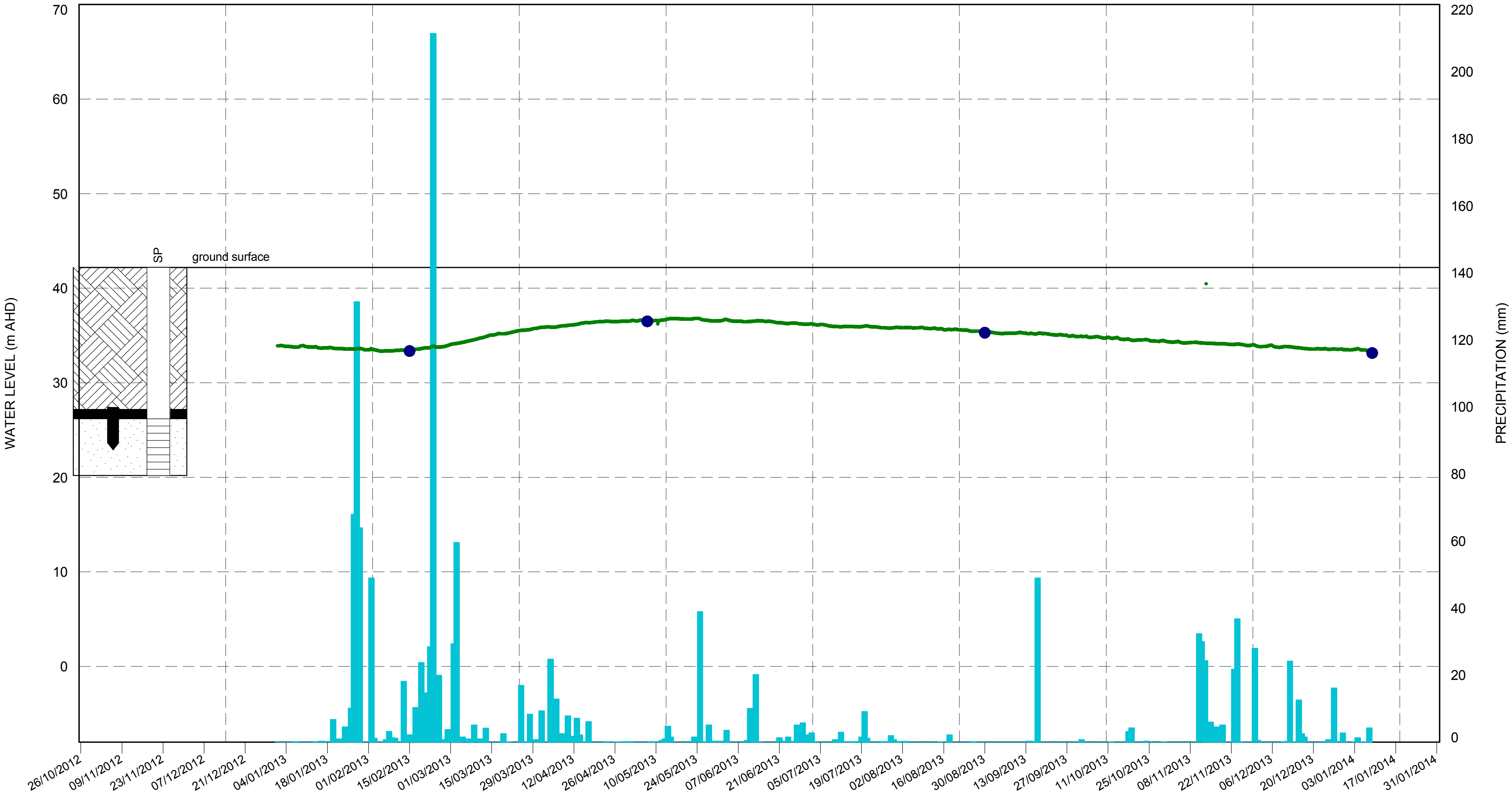
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME
PZ44

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H48 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:50



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:47

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

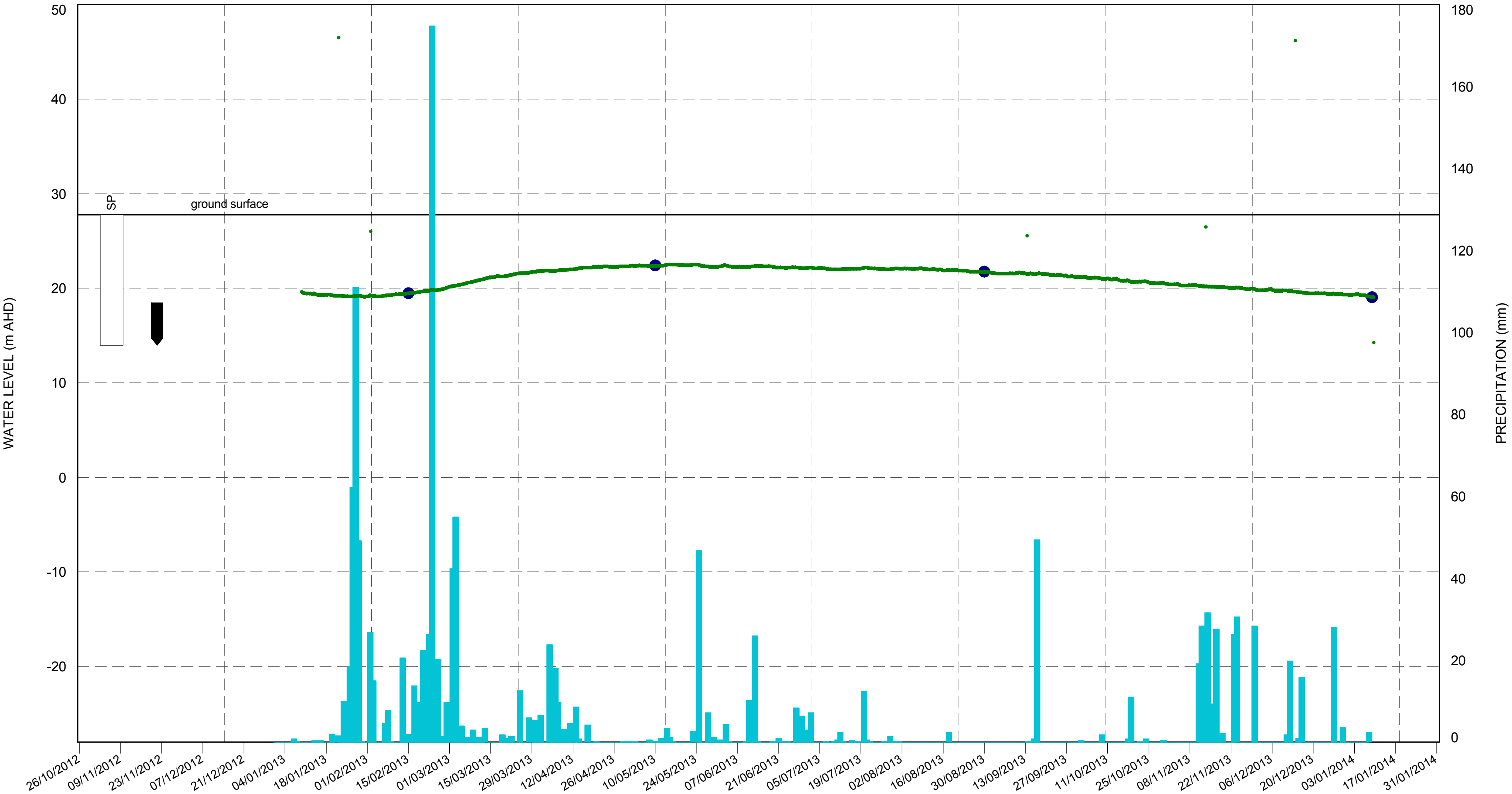
Surface RL: 42.20 m AHD
Borehole Depth: 22.00 m

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date: 01/12/2012
Tip Depth: 19.30 m bgl
RL of Tip: 22.90 m AHD

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date: 01/12/2013
Tip Depth: 22.00 m bgl
RL of Tip: 20.20 m AHD

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH	client:	Roads and Maritime Services
approved	AB	project:	Glenugie to Devils Pulpit Groundwater Monitoring
date	10/03/2014	title:	**GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1139**
scale	AS SHOWN		
original size	A4	project no: GEOTCOFH03059AA-AO	fig no: **FIGURE H1** rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:51

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 27.76 m AHD
Borehole Depth: 13.80 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 13.80 m bgl
RL of Tip: 13.96 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 13.80 m bgl
RL of Tip: 14.23 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

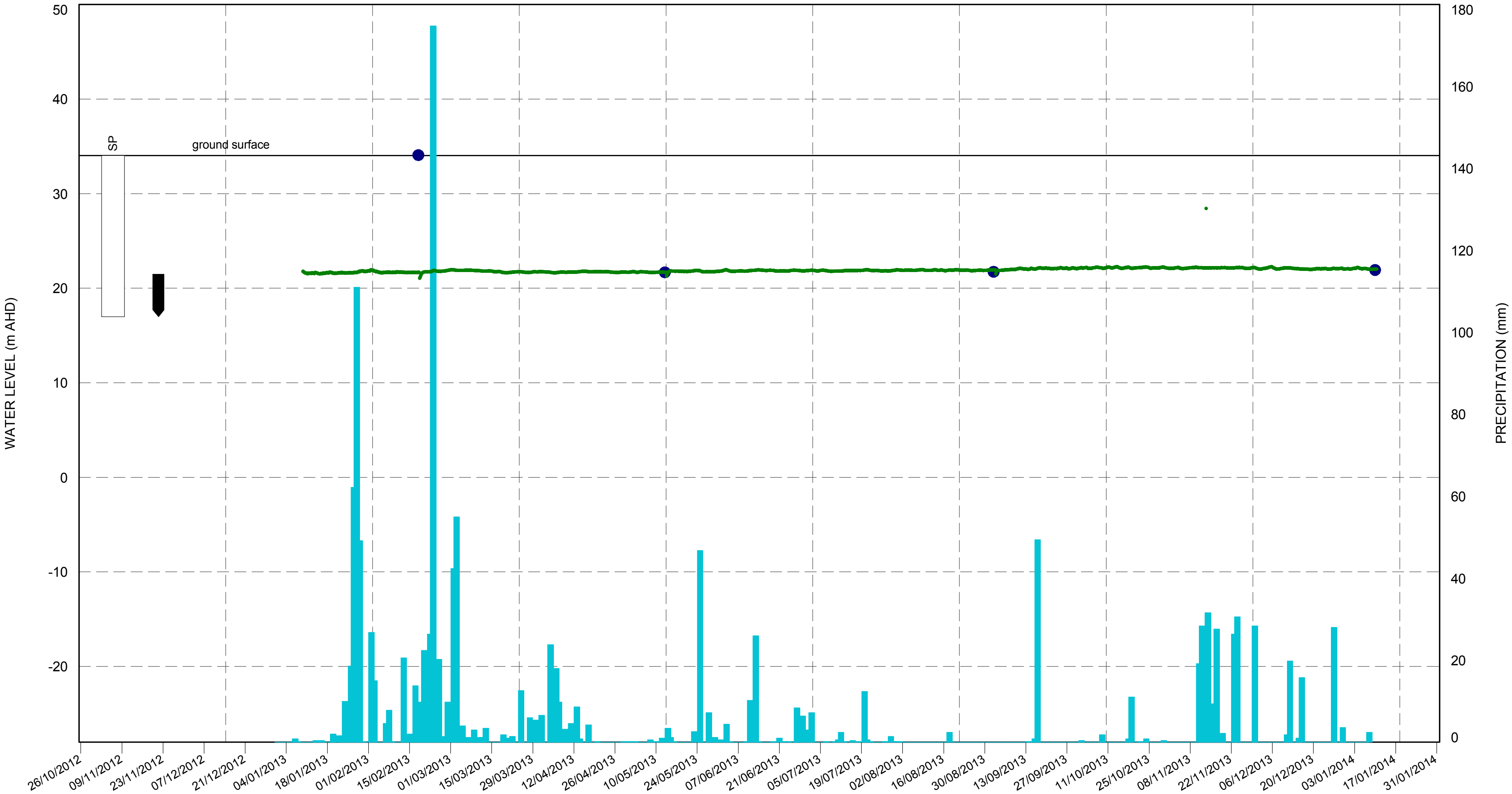
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ45**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H49** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:52

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 34.03 m AHD
Borehole Depth: 17.05 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 17.05 m bgl
RL of Tip: 16.98 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 17.05 m bgl
RL of Tip: 16.96 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

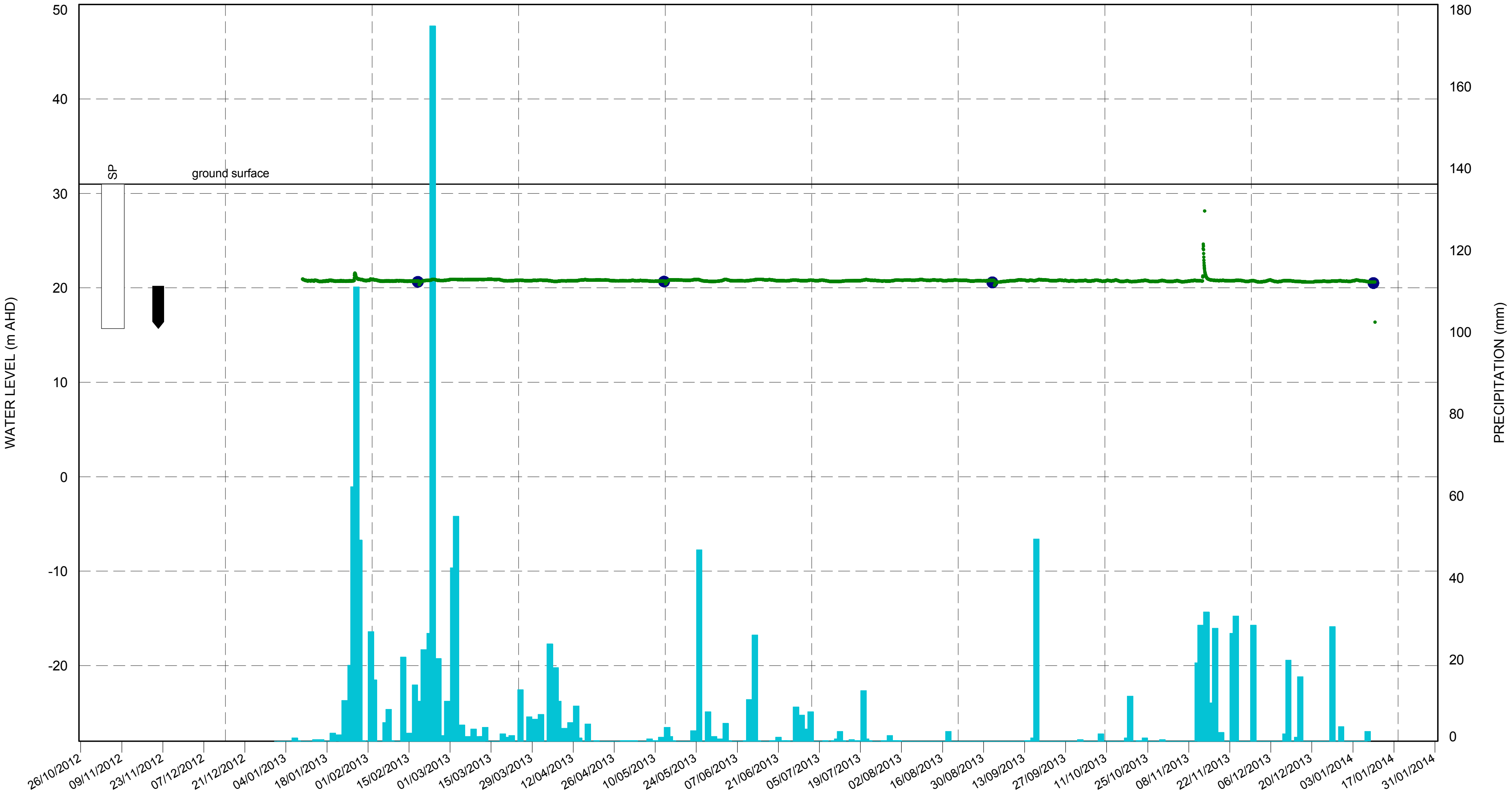
title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ46**

project no: GEOTCOFH03059AA-AO

fig no: **FIGURE H50**

rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:53



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 30.99 m AHD
Borehole Depth: 15.30 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.30 m bgl
RL of Tip: 15.69 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.30 m bgl
RL of Tip: 16.36 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

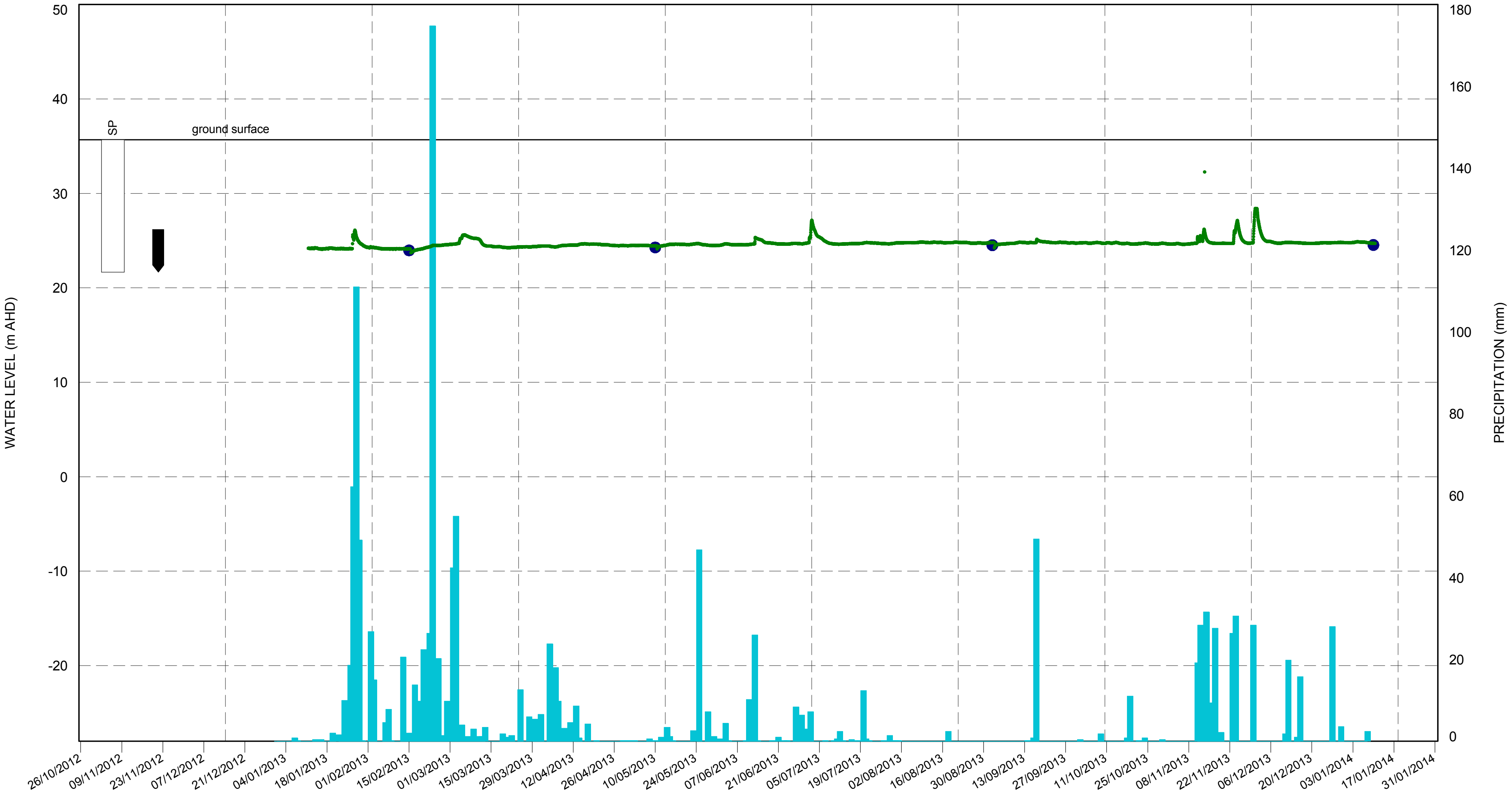
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ47**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H51** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 35.67 m AHD
Borehole Depth: 14.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 21.67 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 22.29 m AHD

drawn	**OH**
approved	**AB**
date	**10/03/2014**
scale	**AS SHOWN**
original size	**A4**

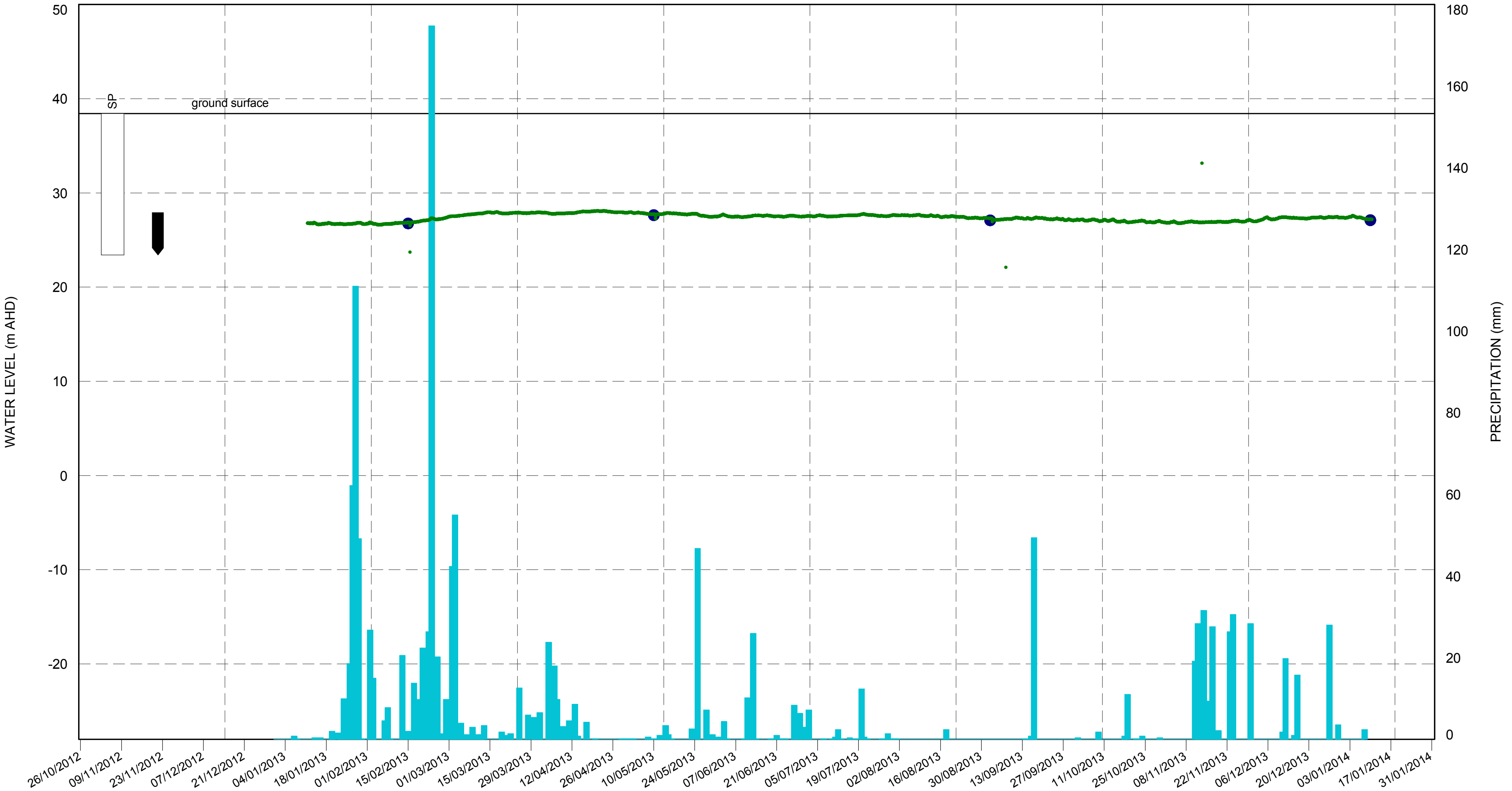
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ48**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H52** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 38.42 m AHD
Borehole Depth: 15.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.00 m bgl
RL of Tip: 23.42 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.00 m bgl
RL of Tip: 23.72 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

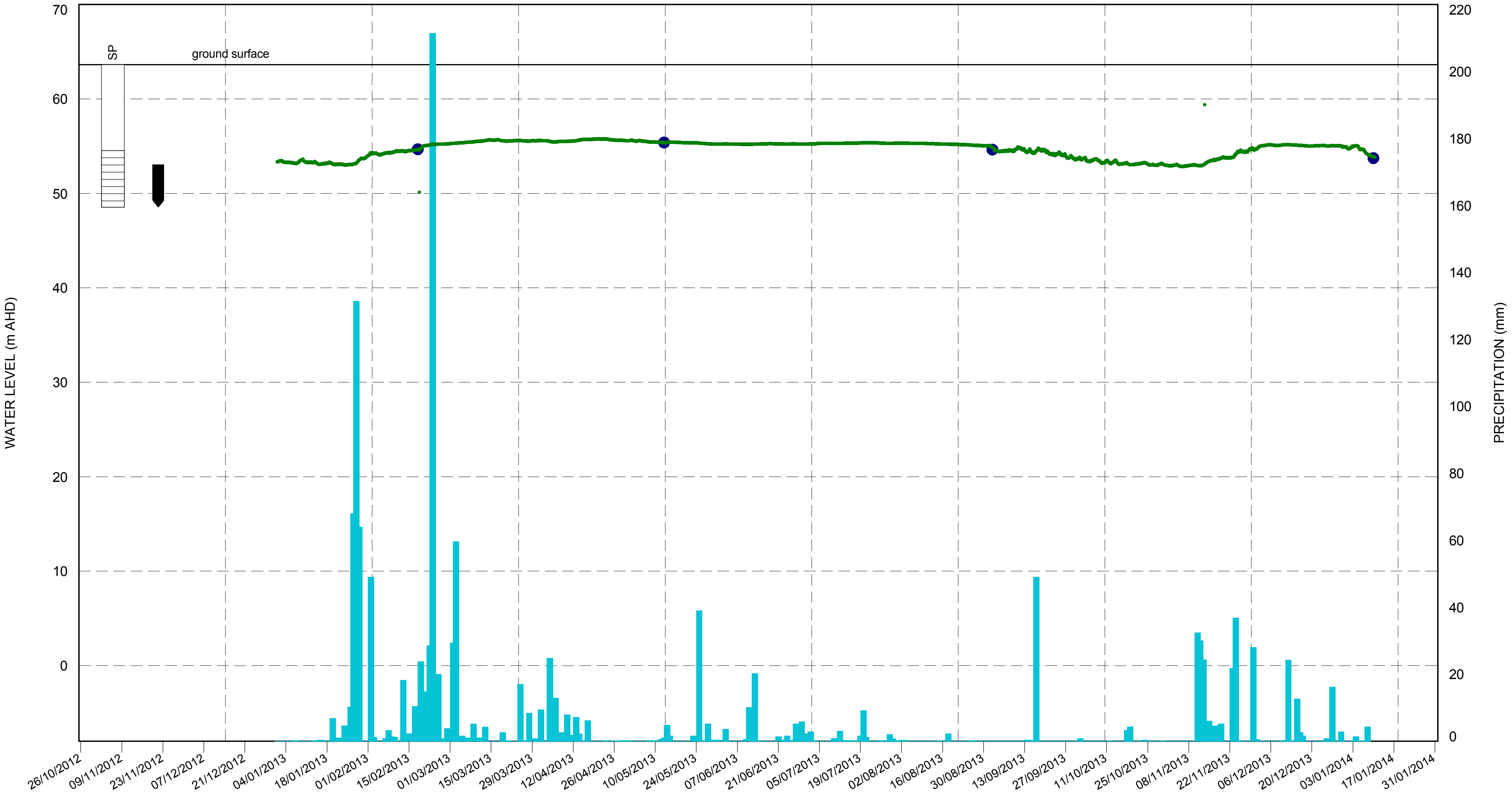
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ49**

project no: GEOTCOFH03059AA-AO
fig no: **FIGURE H53**
rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:48

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 63.64 m AHD
Borehole Depth: 15.10 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.10 m bgl
RL of Tip: 48.54 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.10 m bgl
RL of Tip: 50.15 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

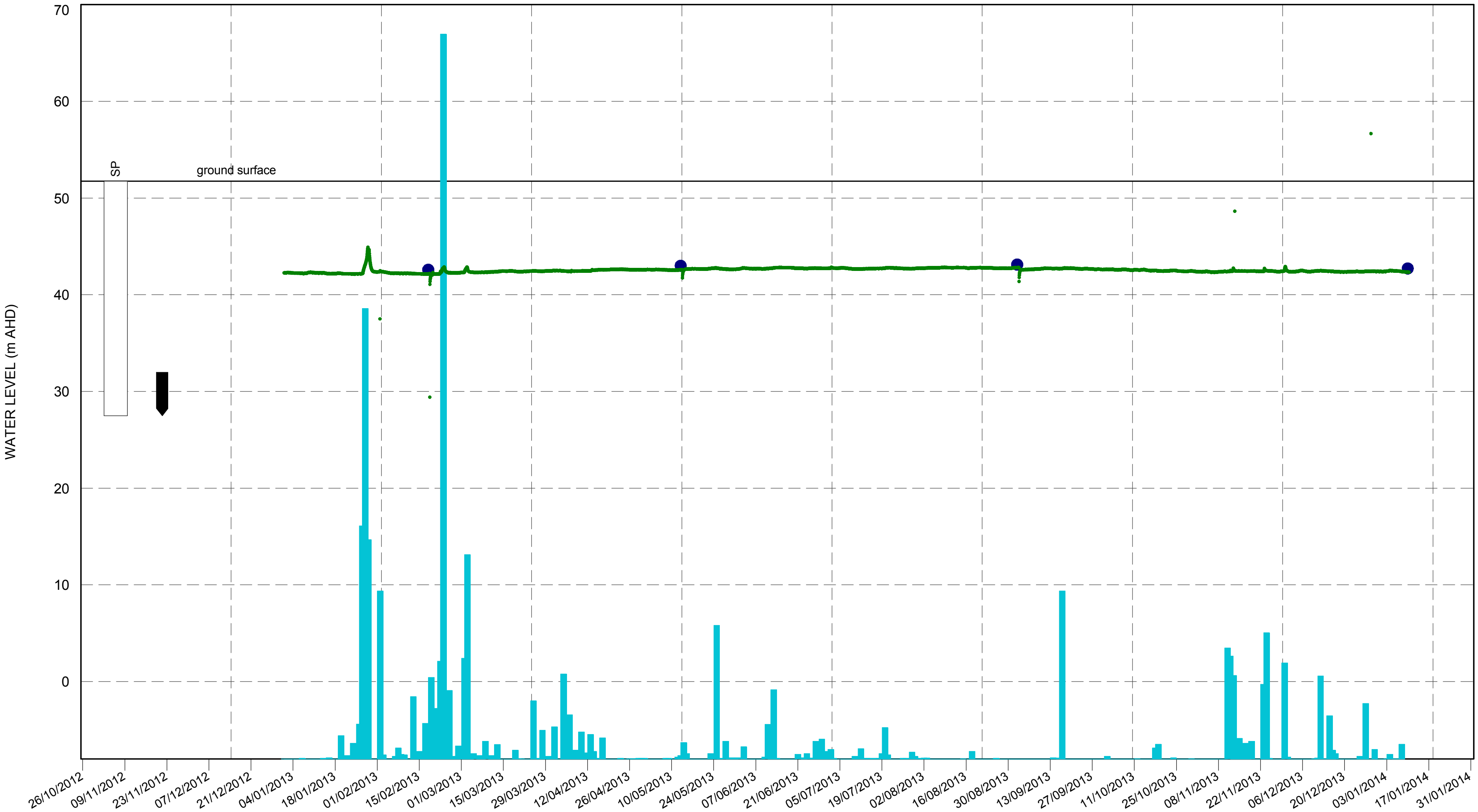
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME**
BH1159

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H2** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 51.74 m AHD
Borehole Depth: 24.25 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 24.25 m bgl
RL of Tip: 22.34 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 24.25 m bgl
RL of Tip: 29.40 m AHD

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

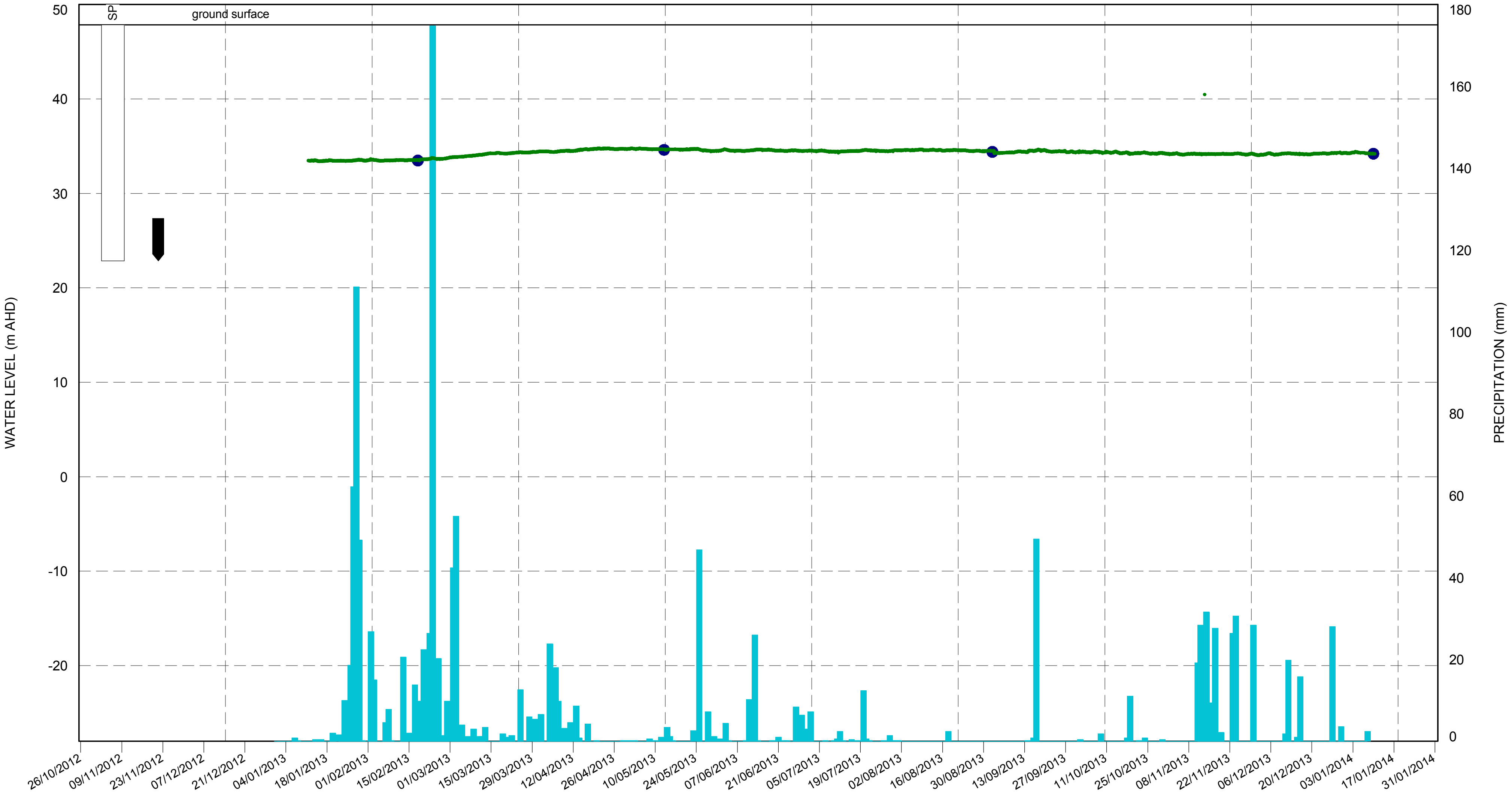
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME
BH1170

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H3 | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 47.85 m AHD
Borehole Depth: 25.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 25.00 m bgl
RL of Tip: 22.85 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 25.00 m bgl
RL of Tip: 25.25 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

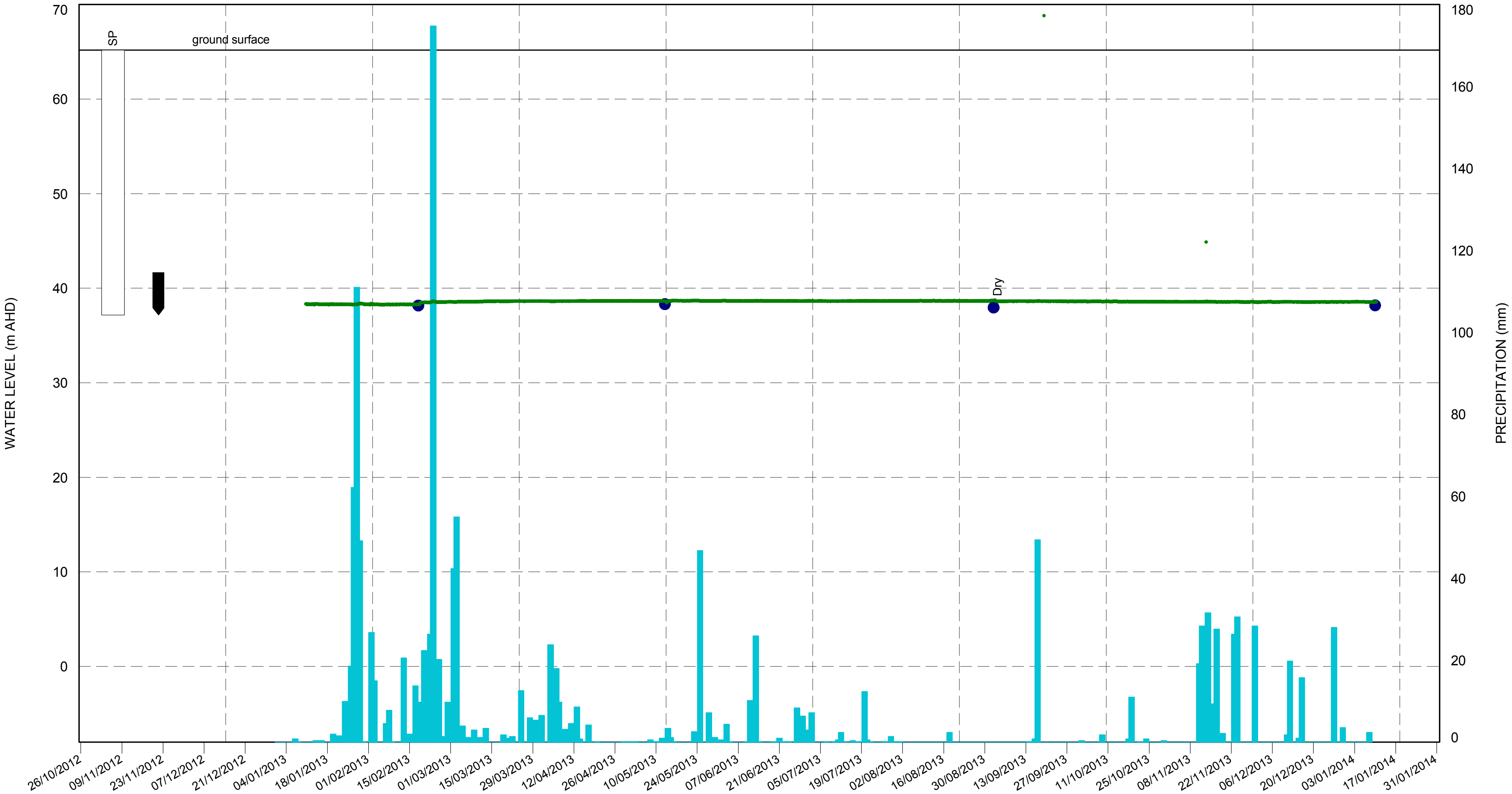
project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ50**

project no: GEOTCOFH03059AA-AO

fig no: **FIGURE H54**

rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 825275.GDW 11/03/2014 12:36

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 65.17 m AHD
Borehole Depth: 28.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 28.00 m bgl
RL of Tip: 37.17 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 28.00 m bgl
RL of Tip: 37.96 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

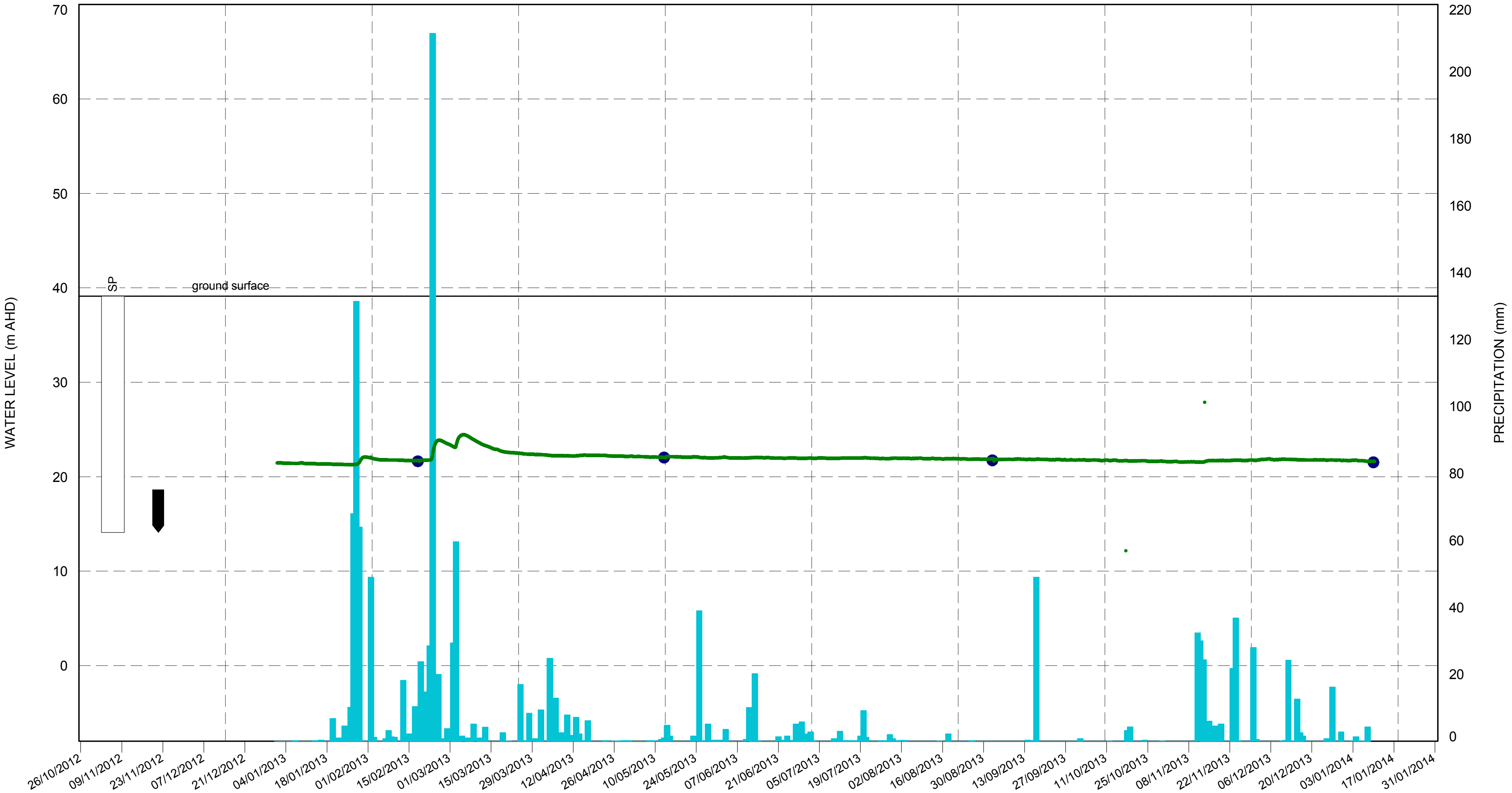
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ51**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H55** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 39.11 m AHD
Borehole Depth: 25.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 25.00 m bgl
RL of Tip: 14.11 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 25.00 m bgl
RL of Tip: 17.20 m AHD

drawn	**OH**
approved	**AB**
date	**10/03/2014**
scale	**AS SHOWN**
original size	**A4**

coffey

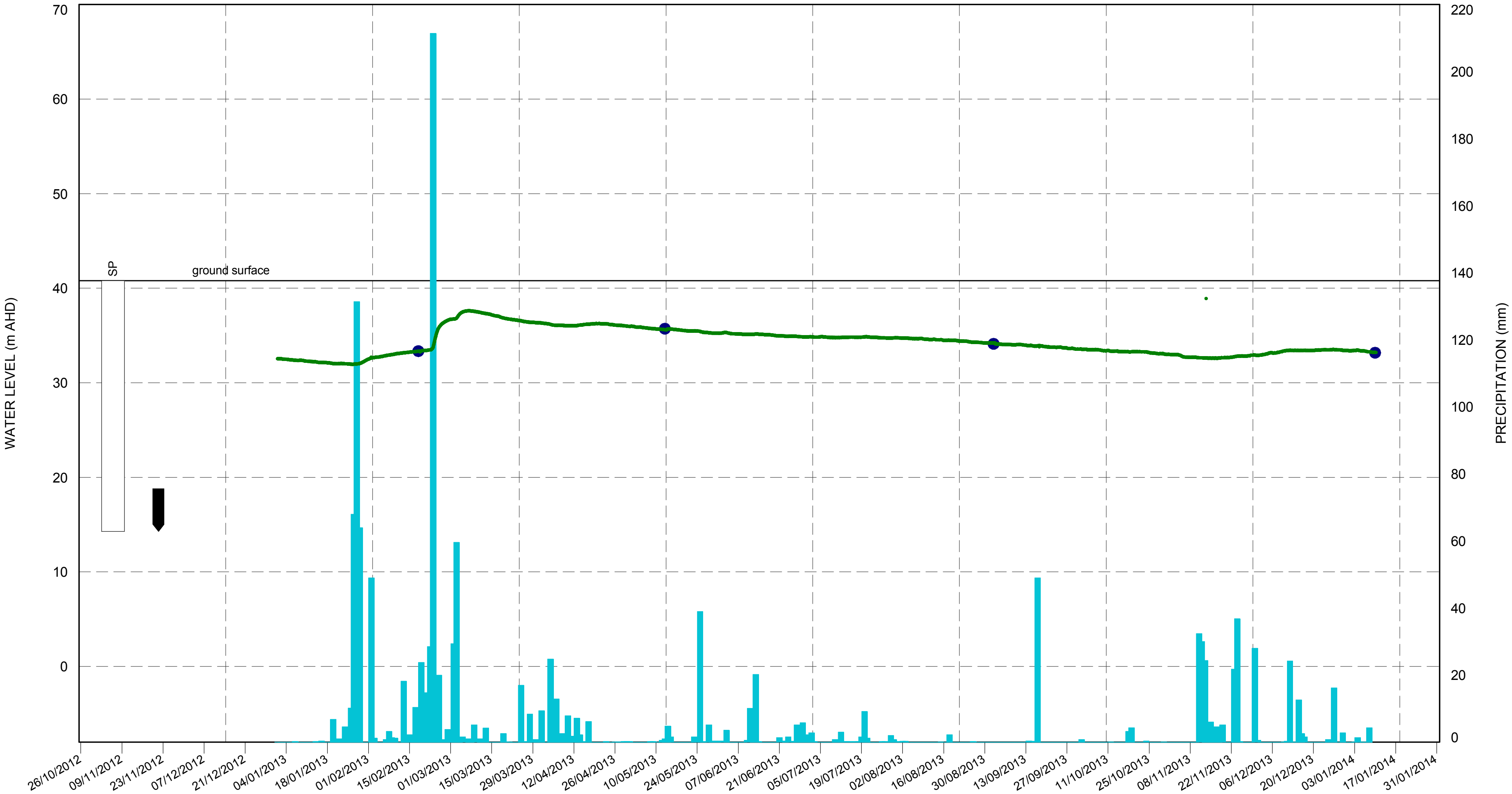
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1187**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H4** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:50



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 40.79 m AHD
Borehole Depth: 26.50 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 26.50 m bgl
RL of Tip: 14.29 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 26.50 m bgl
RL of Tip: 17.86 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

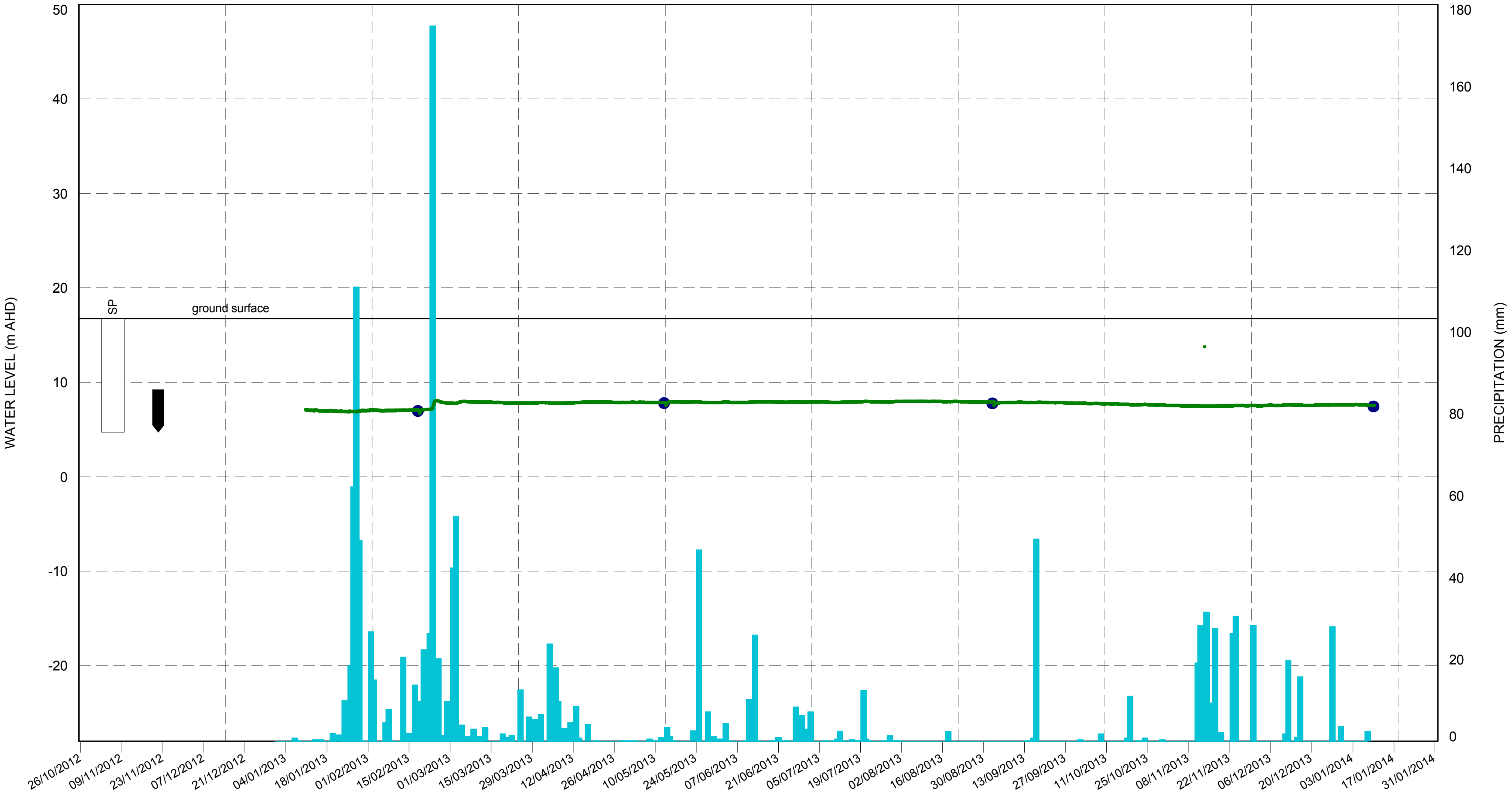
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1197**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H5** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:51



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 16.72 m AHD
Borehole Depth: 12.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 12.00 m bgl
RL of Tip: 4.72 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 12.00 m bgl
RL of Tip: 5.48 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

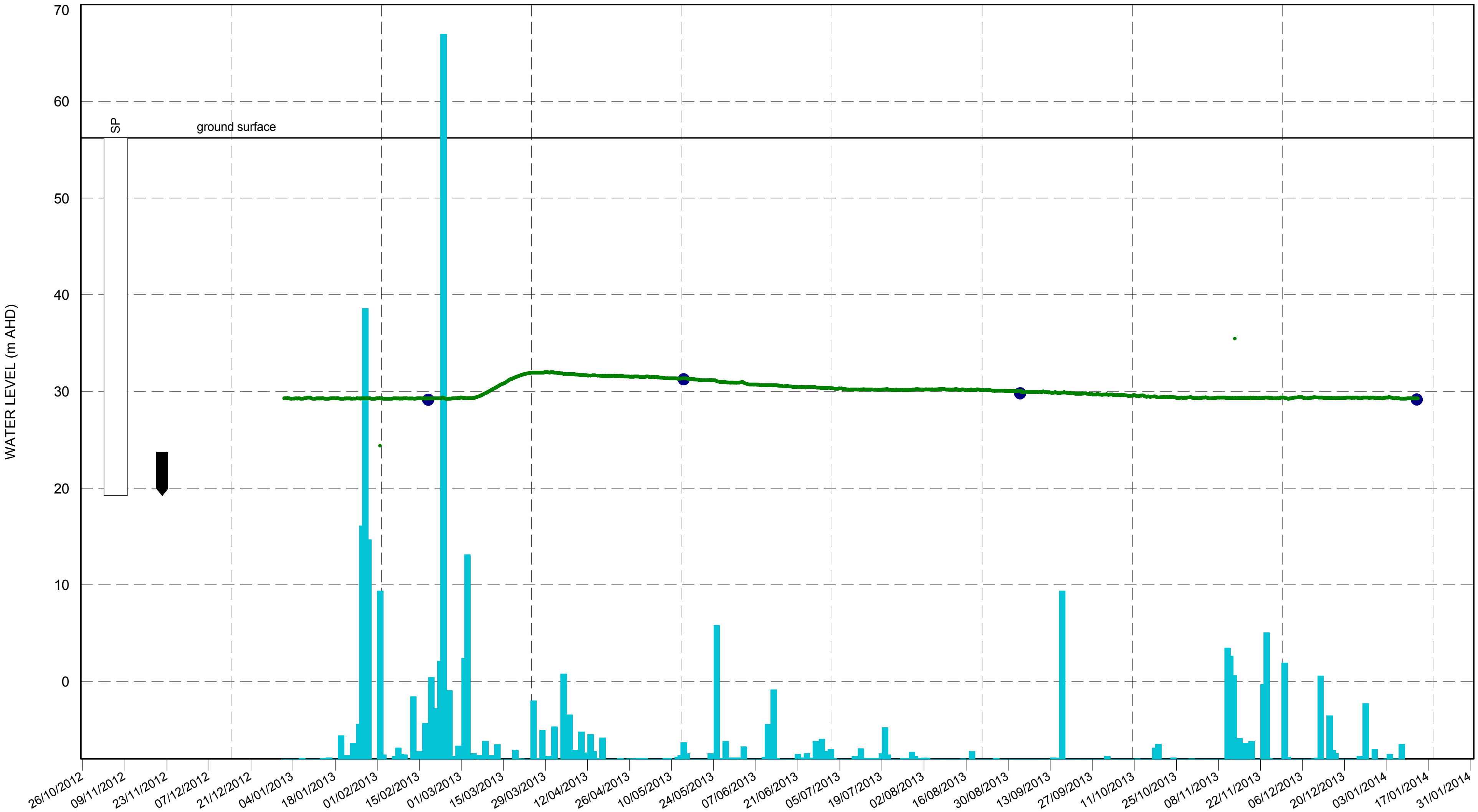
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ52

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H56 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:52



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 56.22 m AHD
Borehole Depth: 37.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 37.00 m bgl
RL of Tip: 19.22 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 37.00 m bgl
RL of Tip: 22.53 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

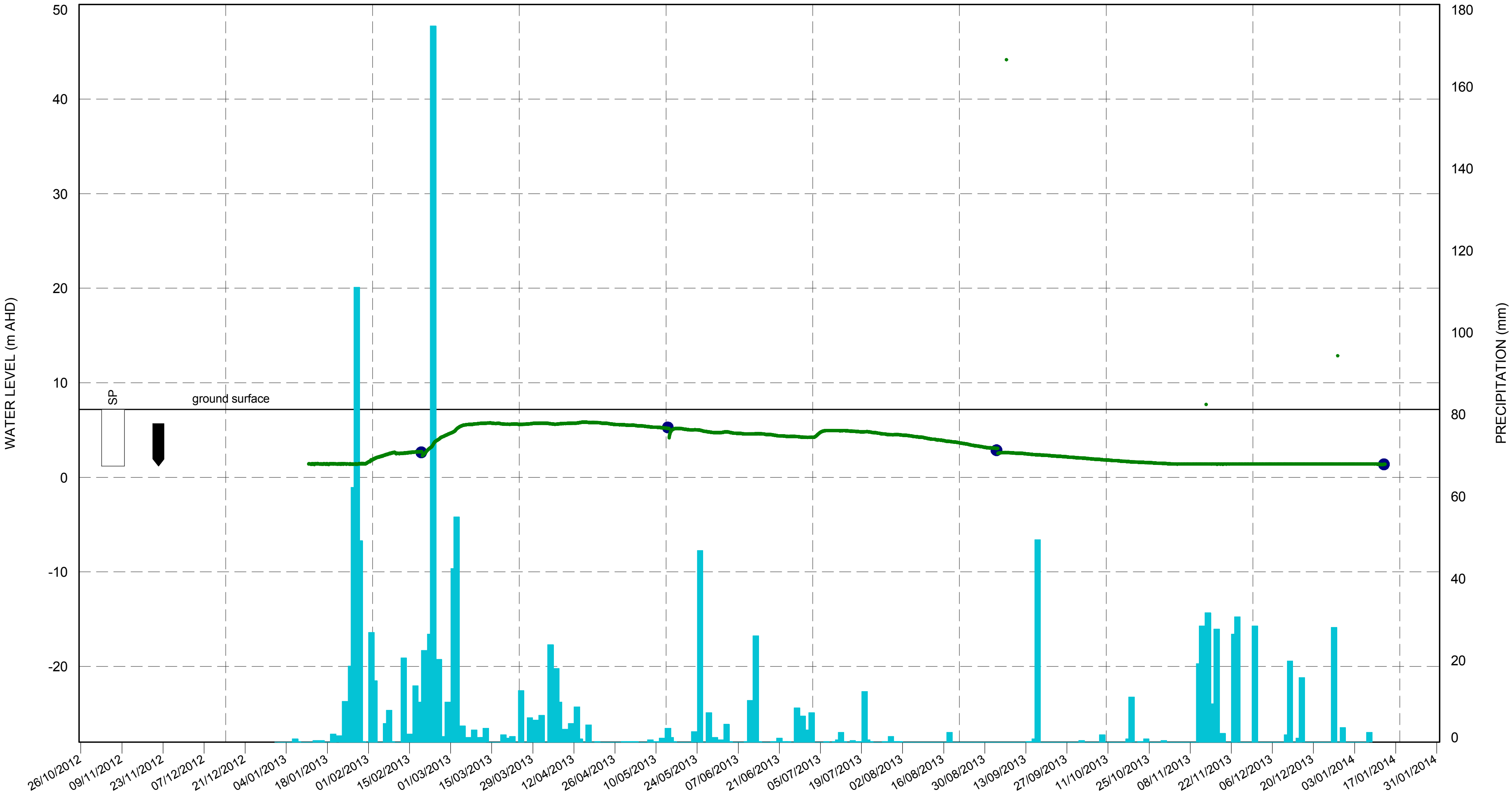
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1200**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H6** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:00

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.19 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 1.19 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 1.38 m AHD

drawn	**OH**
approved	**AB**
date	**10/03/2014**
scale	**AS SHOWN**
original size	**A4**

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ53**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H57** | rev:

Appendix C

Section 4 - Tyndale to Maclean: Pre-Construction Monitoring Results

Section 4: Surface Water Monitoring Locations and associated Sensitive Receiving Environments

Surface Water Sample Locations / Waterway	*Waterway Description*	*Sensitive aquatic receiving environments and groundwater dependent ecosystems*
SW12 – South Arm Clarence River SW23 – Shark Swamp Overflow SW13 – Shark Creek SW14 – Edwards Creek	The waterways in Section 4 are tidally influenced estuarine systems dominated by saline conditions. The exception is the upstream margins of Shark Creek which are assessed to be a lowland freshwater ecosystem.	▪ The highway upgrade alignment at Shark Creek is nearby to SEPP 14 Wetland No. 232, located on the eastern side and upstream of the project. ▪ Key fish habitats are assessed to be present in South Arm (Clarence River), and Shark Creek.

Source: Table 1 in Coffey Geotechnics (2014c).

Section 4: Surface Water Monitoring – Overview of Results

Physical properties

Temperature generally exhibited a gradual increase generally from the mid-teens (15-16°C) in winter up to the high 20s (around 26-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water creeks and tidal waterways.

Turbidity and total suspended solids (TSS) data varied greatly with some correlation between high TSS results and wet weather as would normally be anticipated. There was also a generally weak correlation between turbidity and TSS.

Chemical properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. Median pH levels were generally in the range of 4.5 to 6.7.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period. With the exception of level spikes caused by rainfall.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 0.18 mg/L. Total Nitrogen values were generally less than 1.0 mg/L. However higher Nitrogen values were recorded at sample point SW23

Heavy metals

Heavy metals were generally below detection limits for all sample locations.

Summary of Visual Observations and Sampling Results

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW23 Shark Swamp Overflow (Downstream) Ch. 73,400	▪ Shark swamp overflow is a permanent water course (cane drain) located within private property (Lot 24 DP1007618). There was some variation in the sampling point due to flooding of the cane paddocks following heavy rainfall events. The sample point varied from the outlet adjacent to the Pacific Highway to 700m down along the cane drain. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity with generally slow flows to stagnant water. There were moderate flows in Round 1 & 11a and fast flows observed in Round 2 (February). ▪ Water levels were high during February (Round 1 & 2) and low during Round 8 – 10 & 12. Normal water levels remaining months.	▪ O&G: <5-6.5mg/L ▪ TSS: <5-170mg/L ▪ TP: <0.01-0.21mg/L ▪ TN: 0.3-9.1mg/L ▪ DO: 1.52-11.89mg/L ▪ EC: 119.3-2158µS/cm ▪ pH: 3.38-6.49 ▪ Temp: 15.90-30.7ºC ▪ NTU: 4-46.6
SW13 Shark Creek (Tidal) Ch. 75,000	▪ Shark Creek is a large Creek system, adjacent to Gallaghers Lane with the sample location within the road reserve up gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. There were moderate flows during the wet weather event in February (Round 2). ▪ Water levels were high in February (Round 2) and the remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-38mg/L ▪ TP: <0.01-0.07mg/L ▪ TN: 0.33-1.2mg/L ▪ DO: 1.3-9.84mg/L ▪ EC: 123.5µS/cm-7.40mS/cm ▪ pH: 3.78-7.16 ▪ Temp: 15.1-26.8ºC ▪ NTU: 4.18-62.1
SW14 Edwards Creek (Downstream) Ch. 80,200	▪ Edwards Creek is a tidal creek system, adjacent to the Pacific Highway with the sample location within the road reserve down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during the monitoring program with generally slow flows to stagnant water observed. There were moderate flows observed during Round 1, 3 & 4 (February, March & April). ▪ Water levels were high in February (Round 2), the Creek was low during the Round 8, 10 & 12 (August, October & December). The remaining months were observed as normal water levels.	▪ O&G: <5-8.5mg/L ▪ TSS: <5-34mg/L ▪ TP: <0.01-0.18mg/L ▪ TN: 0.14-2mg/L ▪ DO: 1.03-9.65mg/L ▪ EC: 159.2µS/cm-7.96mS/cm ▪ pH: 3.71-7.18 ▪ Temp: 16.3-28.0ºC ▪ NTU: 3.61-32.30

Note: * Ch. = Highway Chainage

Section 4: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 4							
SW23 (SW4-01 and SW4-02)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil & Grease	mg/l	2.77	1.03	2.5	6.5	2.5	2.50	-	
Suspended Solids	mg/l	21.91	41.98	2.5	170	9	23.00	-	
Total Phosphorus as P	mg/l	0.10	0.13	0.005	0.5	0.05	0.12	-	
Total Nitrogen as N	mg/l	1.53	2.27	0.3	9.1	0.7	1.34	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.15	2.57	1.52	11.89	7.54	8.51	5.10	
Conductivity	µs/cm	1008.03	627.95	119.3	2158	1144	1467.20	234.00	
pH		4.81	1.03	3.38	6.49	4.54	5.90	3.93	
Temperature	°C	22.70	4.98	15.9	30.7	22.7	26.36	-	
Turbidity	NTU	36.57	82.52	4	331	10.5	29.54	-	
SW13 (SW4-03 and SW4-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	16.59	12.42	2.5	38	11	31.00	-	
Total Phosphorus as P	mg/l	0.07	0.13	0.005	0.5	0.02	0.06	-	
Total Nitrogen as N	mg/l	0.60	0.25	0.33	1.2	0.51	0.72	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.05	2.77	1.3	9.84	7.05	8.06	3.15	
Conductivity	µs/cm	673.95	518.34	123.5	1548	447.5	1156.20	328.20	
pH		6.05	1.10	3.78	7.16	6.24	7.13	5.40	
Temperature	°C	21.99	3.93	15.1	26.8	22.8	25.74	-	
Turbidity	NTU	16.09	16.11	4.18	62.1	11.1	15.86	-	
SW14 (SW4-05 and SW4-06)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil & Grease	mg/l	2.90	1.55	2.5	8.5	2.5	2.50	-	
Suspended Solids	mg/l	13.37	9.71	2.5	34	13	19.40	-	
Total Phosphorus as P	mg/l	0.17	0.44	0.005	1.75	0.03	0.15	-	
Total Nitrogen as N	mg/l	0.69	0.46	0.14	2	0.53	1.00	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.18	2.90	1.03	9.65	8.63	9.63	4.97	
Conductivity	µs/cm	1258.51	1640.13	159.2	4670	332	1728.40	199.12	
pH		6.31	1.07	3.71	7.18	6.72	6.96	5.65	
Temperature	°C	22.70	3.91	16.3	28	22.4	26.26	-	
Turbidity	NTU	13.79	9.68	3.61	32.3	10.9	22.96	-	

Section 4: Groundwater Monitoring – Water Quality Overview

Electrical Conductivity

Values are indicative of freshwater to brackish / saline groundwater conditions with average salinity values ranging between 200 µS/cm (PZ21) to 9,320 µS/cm (PZ09). Generally the 12 well locations with shallower water levels (<5.0m below ground level) found within areas of fill or the bridge locations near Edwards Creek of the south bank of the Clarence River showed larger standard deviations than wells with standing water levels at greater depths located in cuts. The observed variation may be due to these locations proximity to tidal waterways and the influence of wet weather events on groundwater conductivity.

pH

pH, of groundwater in Section 4 show average values ranging from pH 5.68 (PZ55) to pH 10.29 (BH1206). The majority, 19 of 20 locations, had an average pH >6 which indicates a slightly acidic to neutral pH in groundwater throughout Section 4. Little variation occurs in pH with 4 of the 20 wells reporting a standard deviation value >1 pH unit.

Temperature

The average temperature values for the monitoring locations in Section 4 ranged between 20.8◦C to 23.4◦C. The variation in groundwater average temperature values throughout Section 4 is likely to be attributable to seasonal temperature changes and the variable depth of groundwater from the ground surface.

Summary statistics for Groundwater Physico-Chemical Monitoring

Cut/Fill Number	*Borehole Identifier*	Electrical Conductivity (µS/cm)				pH				Temp. (◦C)
		*Med.**	*SD***	*P80*	*P20*	*Med.**	*SD***	*P80*	*P20*	*Med.**
Cut 4-2	BH1206	239	100	297	189	10.54	0.63	10.62	10.05	21.60
	PZ54	556	255	568	352	7.13	1.12	7.22	6.25	21.25
Fill F4-2A	PZ55	1831	1269	2774	702	5.84	1.69	7.07	4.35	22.75
	PZ56	22.75	2.20	23	21	6.23	0.67	6.61	5.70	22.75
Fill F4-2B	PZ57	1496	3755	4912	186	6.78	0.53	7.26	6.55	21.65
	PZ58	5565	3404	6744	3233	6.81	0.48	7.08	6.45	21.55
Fill F4-2C	PZ59	506	423	827	333	7.25	0.99	7.95	6.54	22.10
	PZ60	1536	938	1876	982	6.85	0.67	7.44	6.59	22.20
Cut 4-4	BH1251	308	29	323	283	7.16	0.32	7.32	6.91	20.85
	BH1259	2068	668	2351	1784	6.73	0.16	6.79	6.66	21.20
Cut 4-5	BH1261	1663	2066	3558	132	7.42	0.32	7.53	7.14	22.40
	PZ61	7600	323	7772	7456	6.36	0.53	6.77	6.17	22.15
Fill F4-5	PZ62	2775	1363	3020	1681	6.31	1.62	7.62	6.19	21.80
	PZ63	4500	366	4818	4362	6.59	0.29	6.81	6.36	21.55
Cut C4-6	PZ64	4675	1126	5168	3658	6.61	0.07	6.67	6.56	22.30
	PZ65	Dry								
Cut C4-7	PZ66	Dry								
	BH1359	399	329	639	246	6.68	0.54	6.98	6.33	22.10
Bridges - Edwards Creek	PZ67	1395	1209	1908	882	7.07	0.91	7.45	6.68	22.70
	PZ68	1169	440	1182	719	6.86	0.45	6.98	6.46	22.40
Maclean Int'change	PZ69	2845	2237	4564	876	7.46	1.02	8.13	7.10	21.20
	PZ70	9320	1245	9848	8792	7.17	0.33	7.31	7.02	21.20

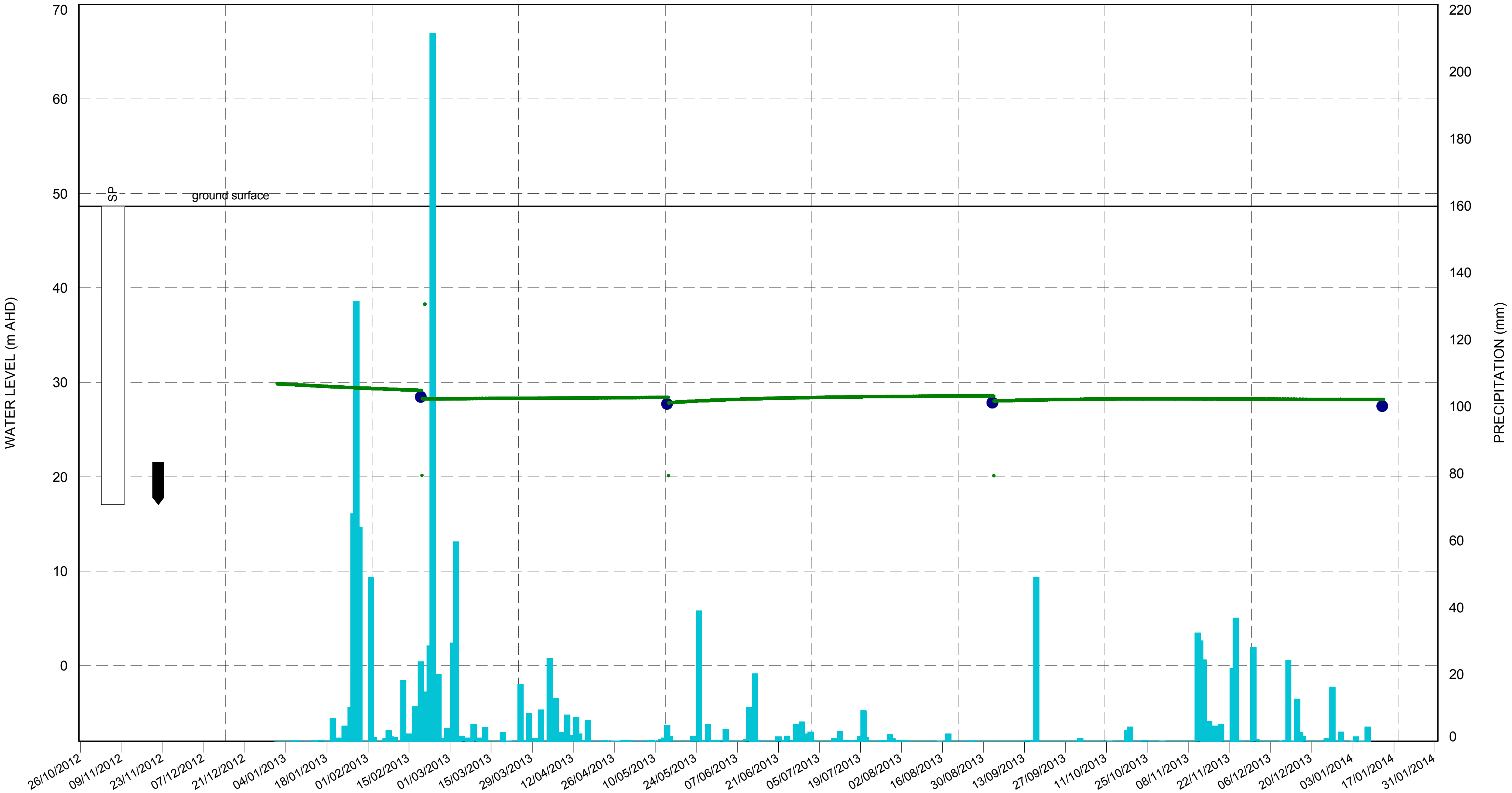
Note: * Med. = Median
** DS = Standard Deviation

Section 4: Groundwater Monitoring – Levels

The typical standing water levels in Section 4 averaged between 0.07m (PZ67) and 22.78m (BH1251) below ground surface. In general, the SWLs observed in areas of proposed fill or bridges in Section 4 were noted to be close to the ground surface (<2m bgs) indicating shallow groundwater. The long term monitoring data indicates that the groundwater levels throughout much of Section 4 are influenced by large rainfall events (e.g. over 100mm rainfall event in January 2013). It should be noted the SWLs are relative to the topography of the monitoring location.

Summary of Groundwater Level Monitoring – Section 4 G2DP Upgrade

Cut/Fill Number	*Monitoring Location*	*Borehole Depth*	*Typical SWL (m below ground level)*		
			AVG	*MED*	*SD*
Cut 4-2	BH1206	31.6	20.78	20.87	0.42
	PZ54	14	6.91	6.14	2.68
Fill F4-2A	PZ55	6	0.57	0.69	0.40
	PZ56	6	1.26	1.29	0.31
Fill F4-2B	PZ57	6	0.62	0.64	0.30
	PZ58	6	0.58	0.84	0.75
Fill F4-2C	PZ59	6	0.62	0.66	0.48
	PZ60	6	0.64	0.63	0.54
Cut 4-4	BH1251	40.2	22.78	23.08	0.97
	BH1259	15.25	14.75	14.75	0.52
Cut 4-5	BH1261	21	13.22	13.27	0.11
	PZ61	8.8	6.81	6.88	0.19
Fill F4-5	PZ62	6	0.64	0.63	0.50
	PZ63	6	0.55	0.54	0.51
Cut C4-6	PZ64	10	7.63	7.65	0.26
	PZ65	11	Dry	Dry	Dry
Cut C4-7	PZ66	14	Dry	Dry	Dry
	BH1359	16.12	5.70	5.67	6.58
Bridges Over Edwards Creek	PZ67	6	0.07	0.00	0.14
	PZ68	6	1.64	2.08	1.11
Maclean Interchange	PZ69	6	0.70	0.69	0.51
	PZ70	6	0.09	0.00	0.17



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 48.65 m AHD
Borehole Depth: 31.60 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 31.60 m bgl
RL of Tip: 17.05 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 31.60 m bgl
RL of Tip: 20.11 m AHD

drawn	**OH**
approved	**AB**
date	**10/03/2014**
scale	**AS SHOWN**
original size	**A4**

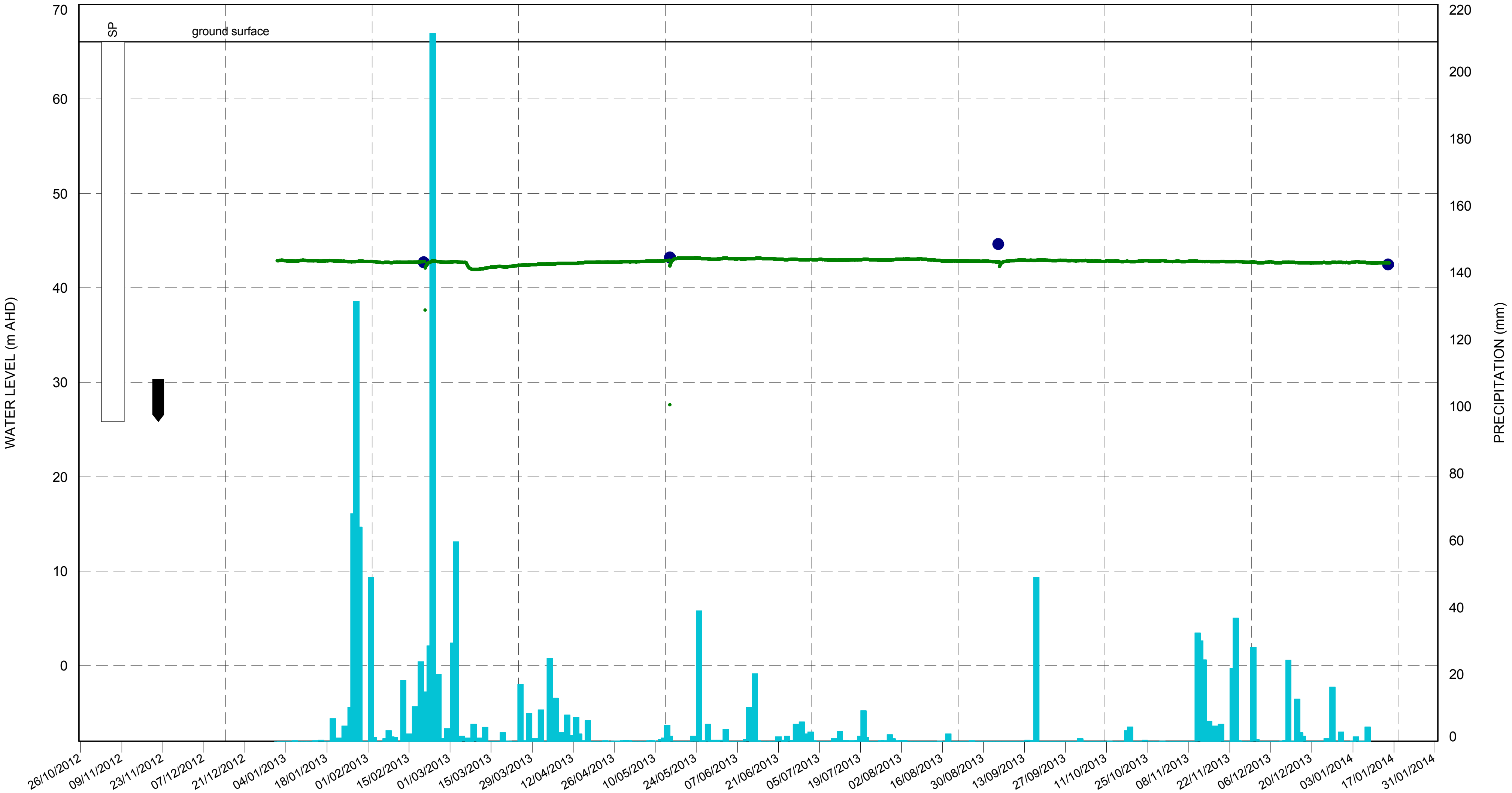
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title:
GROUNDWATER LEVEL AND RAINFALL VERSUS TIME
BH1206

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H7** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 66.04 m AHD
Borehole Depth: 40.20 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 40.20 m bgl
RL of Tip: 25.84 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 40.20 m bgl
RL of Tip: 27.61 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

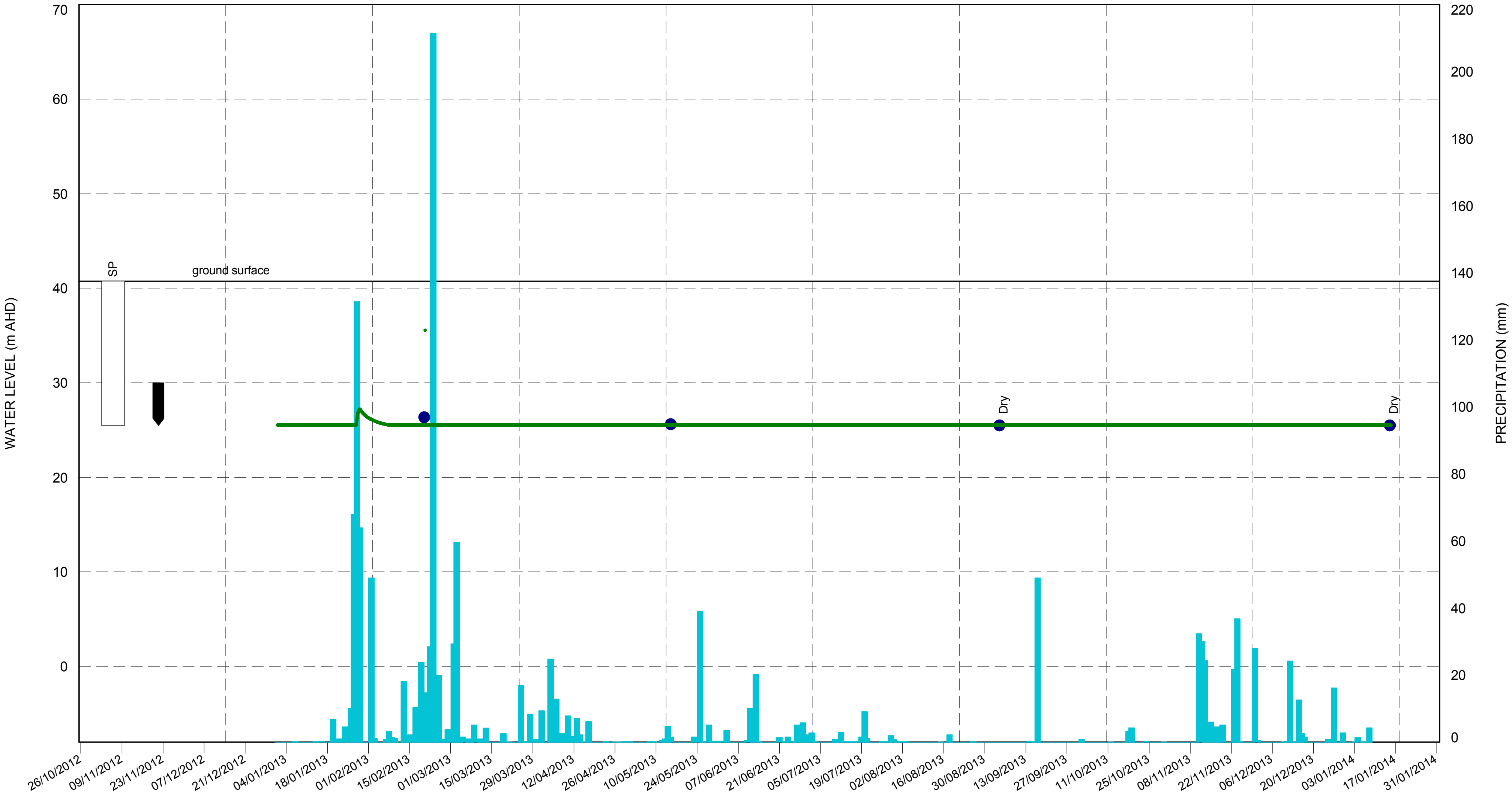
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME**
BH1251

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H8** | rev:



■ Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 40.74 m AHD
Borehole Depth: 15.25 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.25 m bgl
RL of Tip: 25.49 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.25 m bgl
RL of Tip: 25.50 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

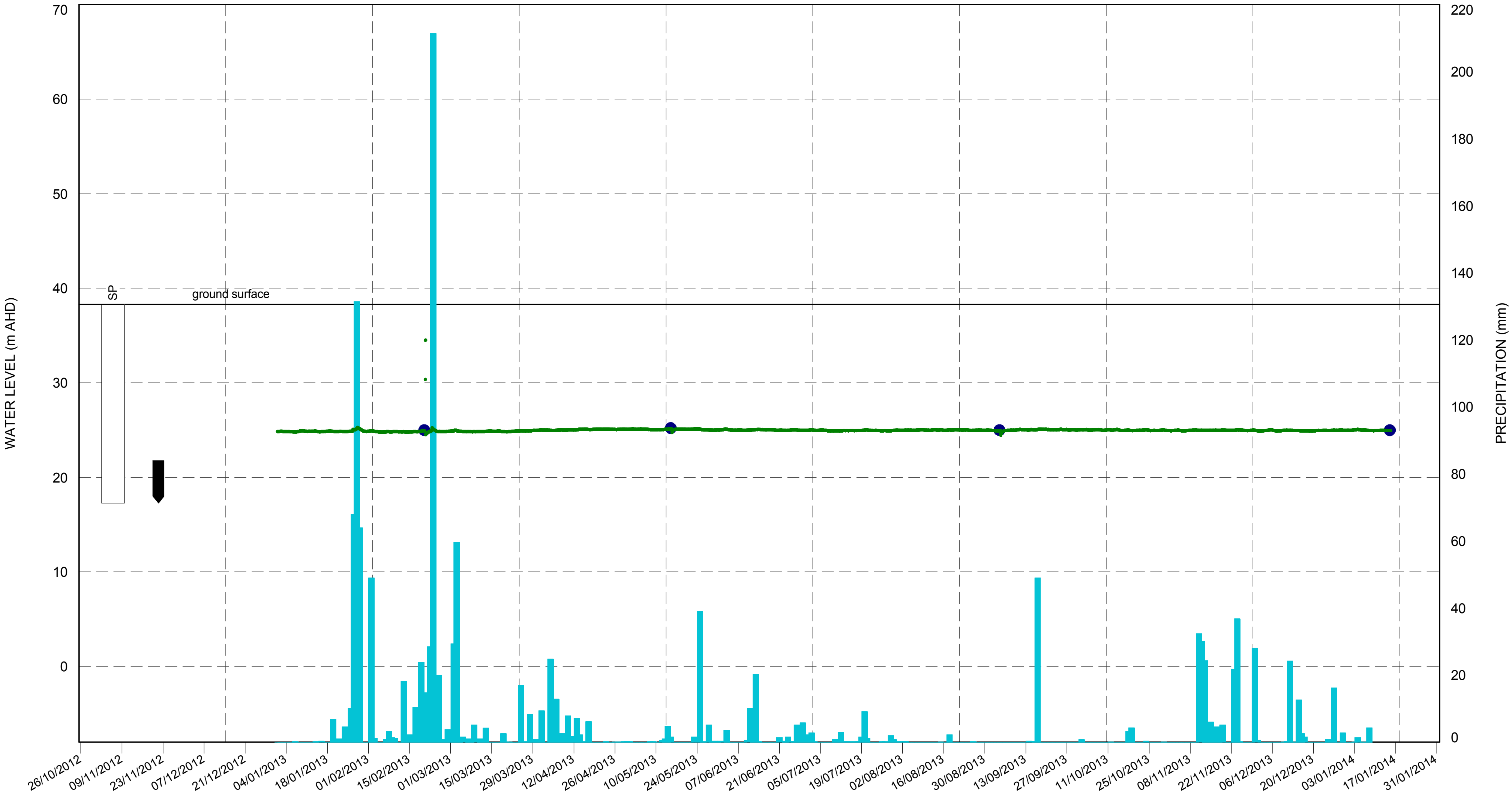
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1259**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H9** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 38.27 m AHD
Borehole Depth: 21.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 21.00 m bgl
RL of Tip: 17.27 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 21.00 m bgl
RL of Tip: 20.30 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1261**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H10** | rev:

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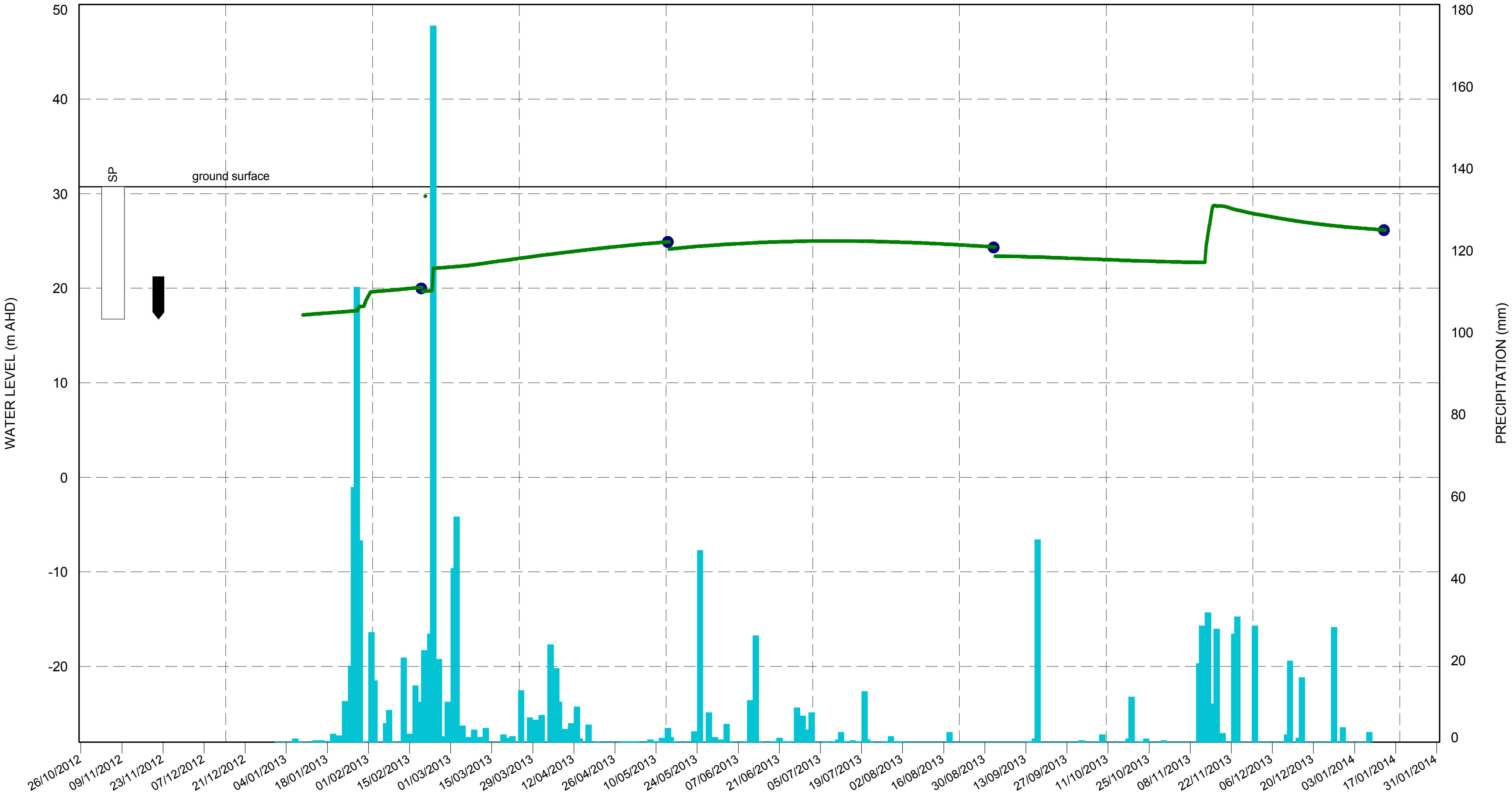

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Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 30.74 m AHD
Borehole Depth: 14.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 16.74 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 17.12 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

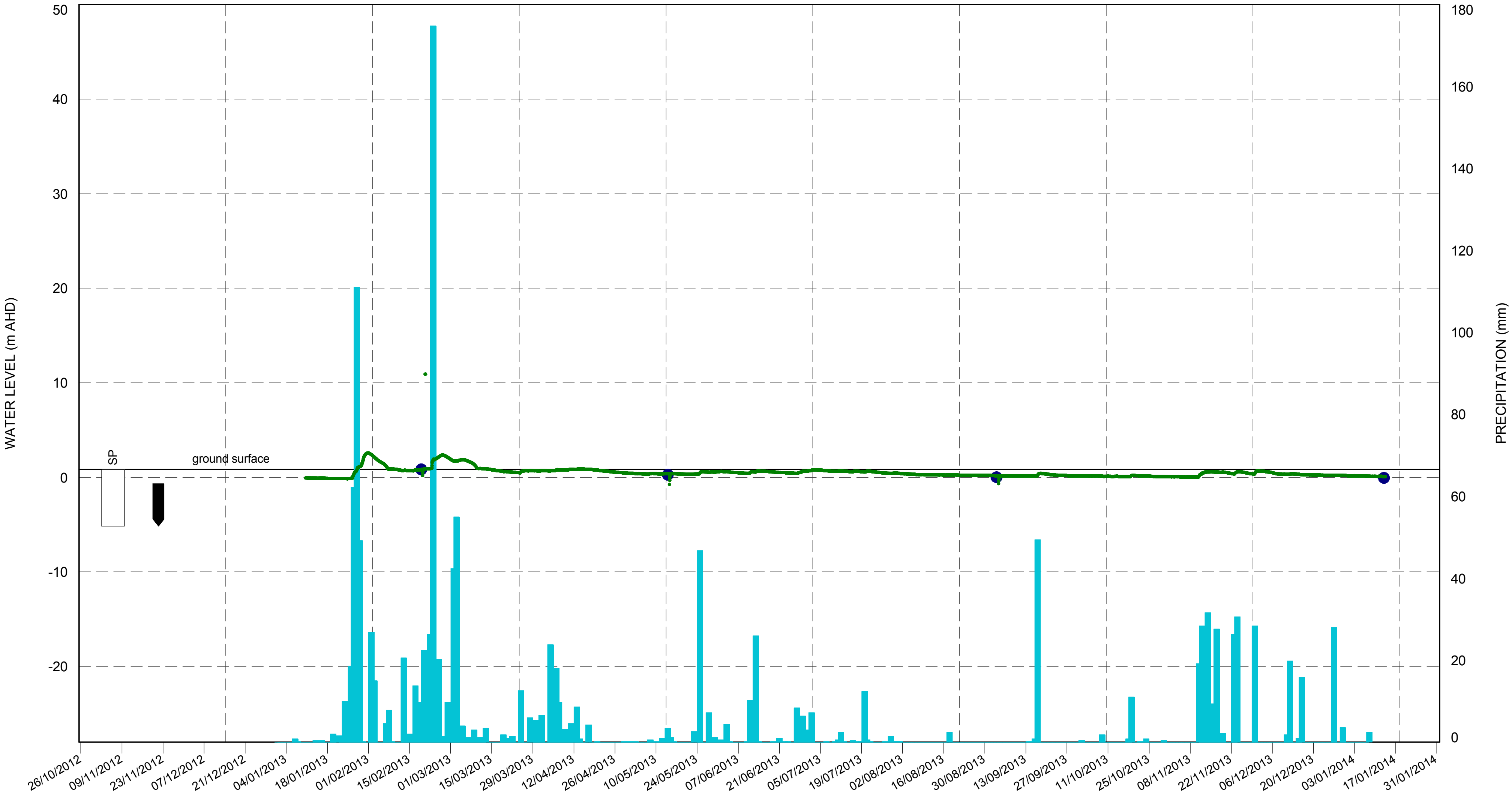
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ54**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H58** | rev:



Bentonite, Concrete, Cuttings, Gravel, Grout, Sand

Surface RL: 0.84 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.16 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.67 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

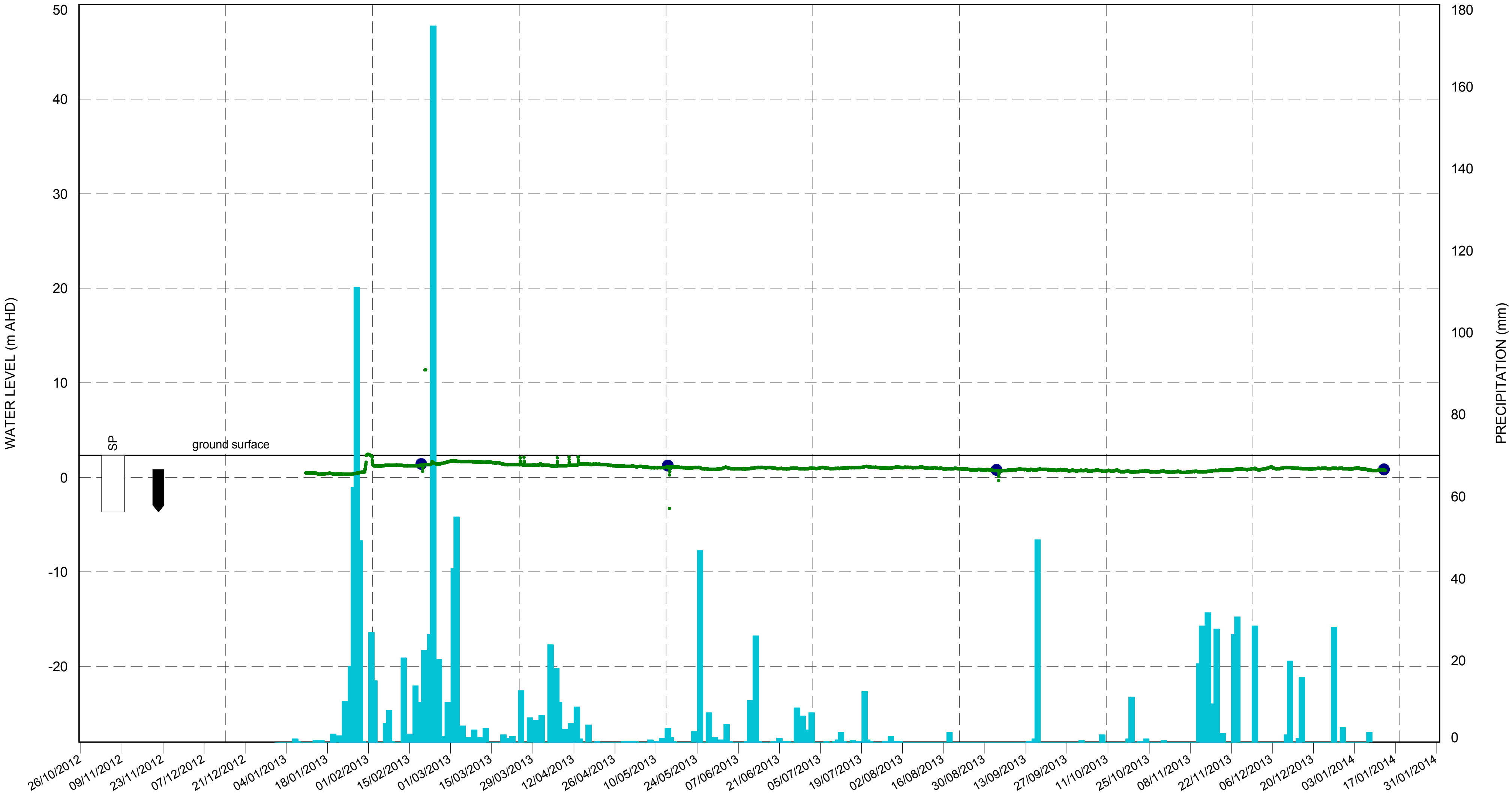
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ55**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H59** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:02



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 2.33 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.67 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.36 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

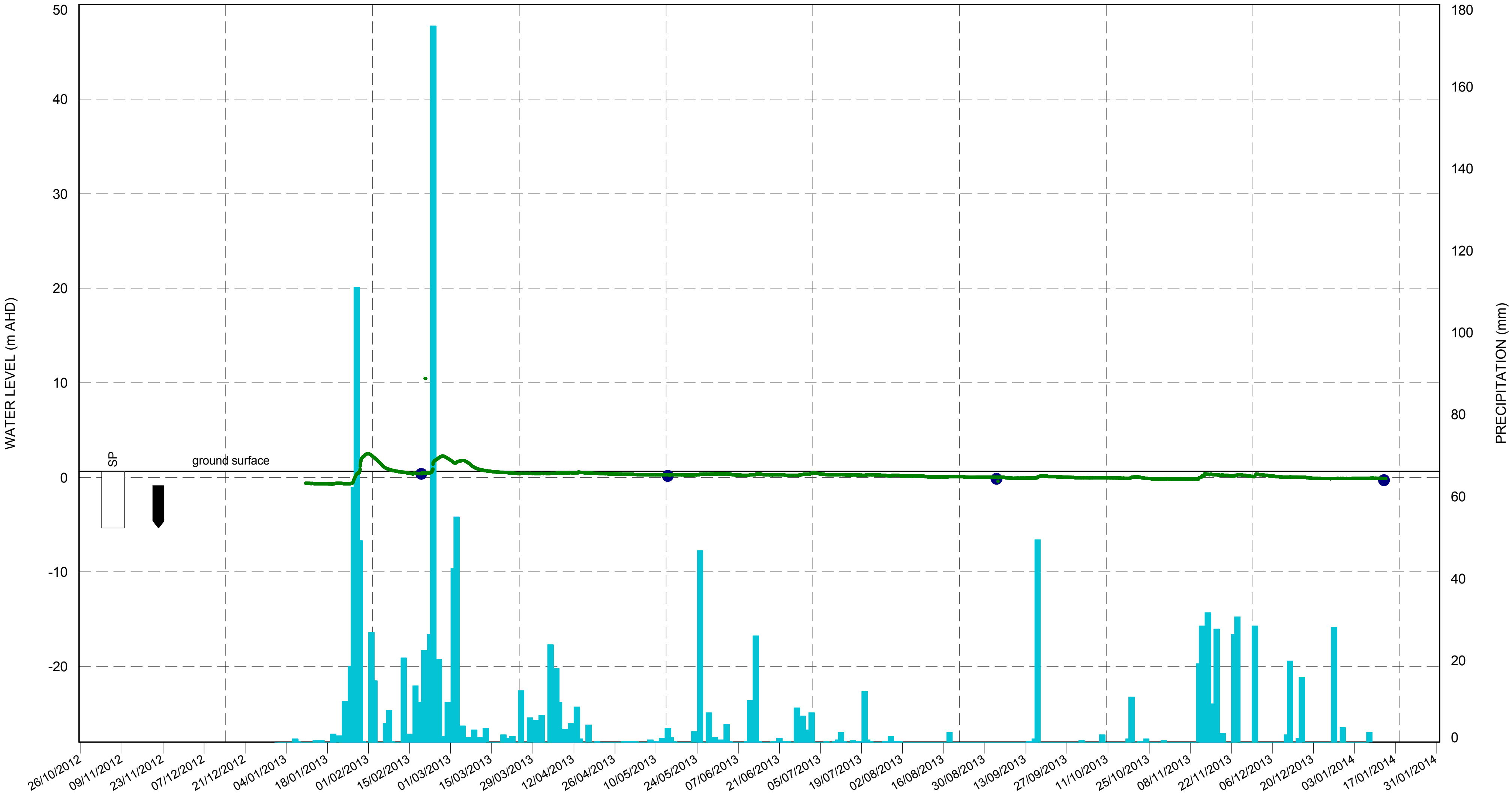
project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ56

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H60 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:04

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:05



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.64 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.36 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.16 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

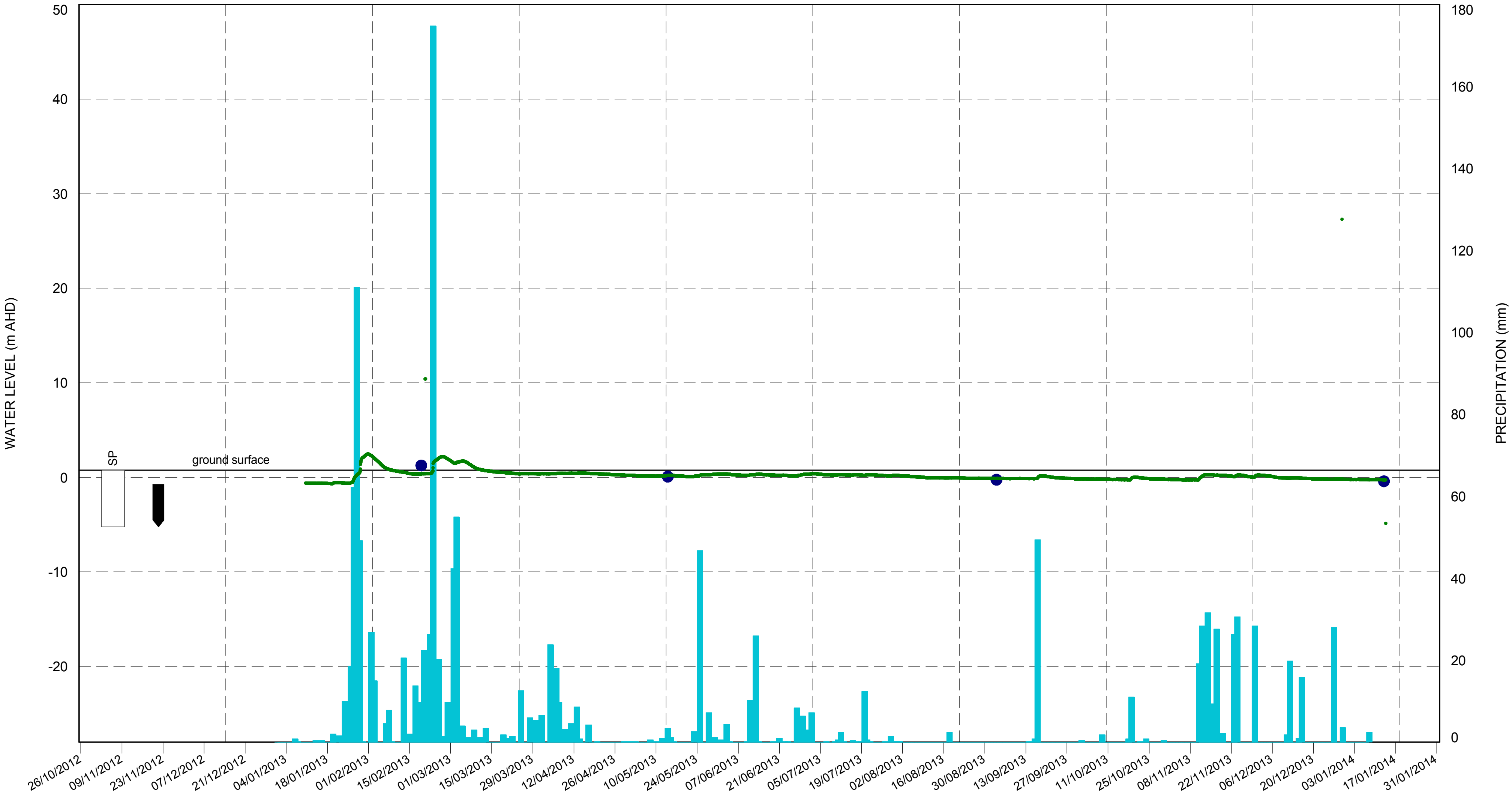
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ57**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H61** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:06

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 0.75 m AHD
Borehole Depth: 6.00 m

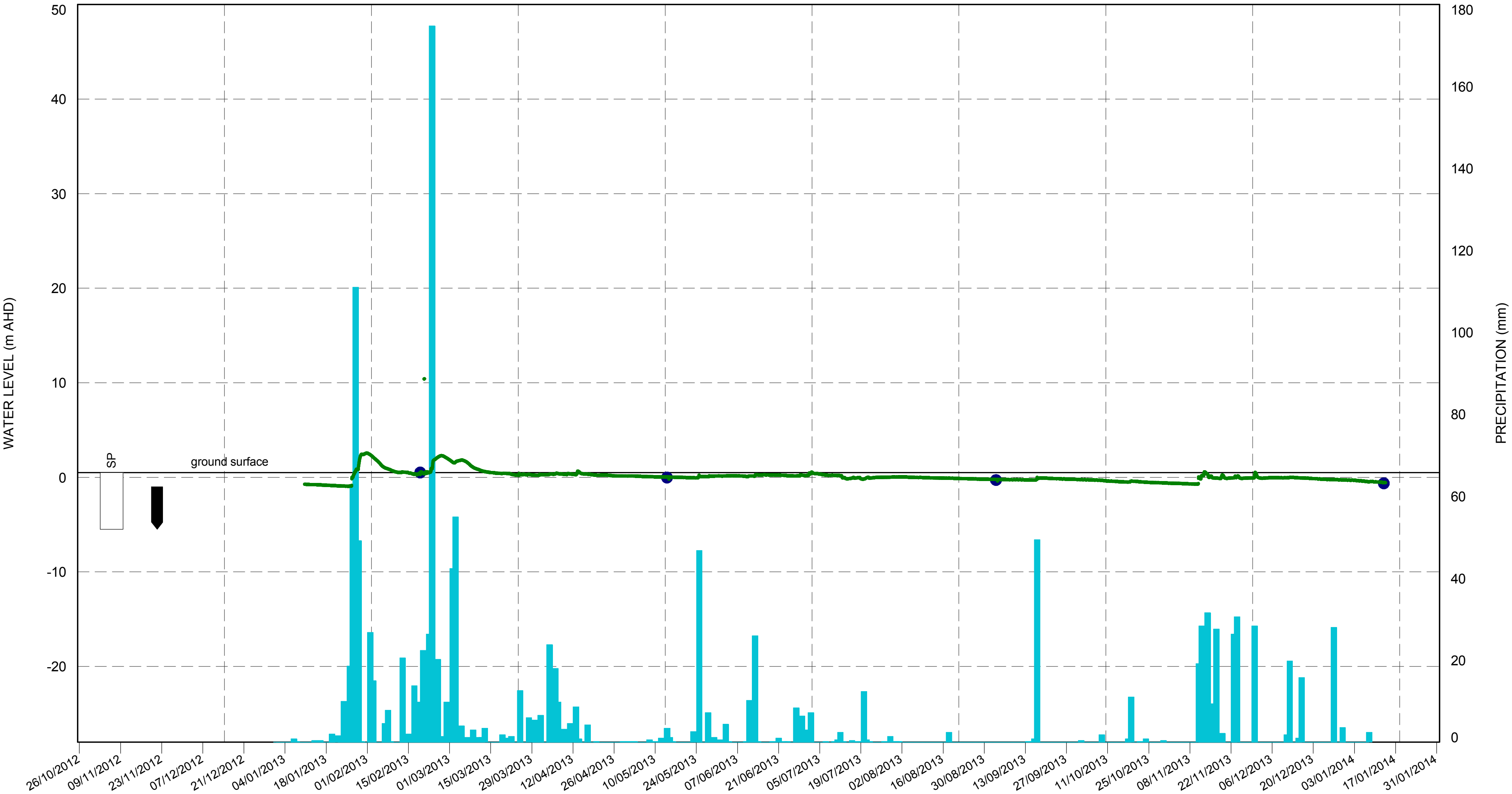
●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.25 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.94 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH	client:	Roads and Maritime Services
approved	AB	project:	Glenugie to Devils Pulpit Groundwater Monitoring
date	10/03/2014	title:	GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ58
scale	AS SHOWN		
original size	A4	project no: GEOTCOFH03059AA-AO	fig no: FIGURE H62 rev:

coffey



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 0.51 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.49 m AHD

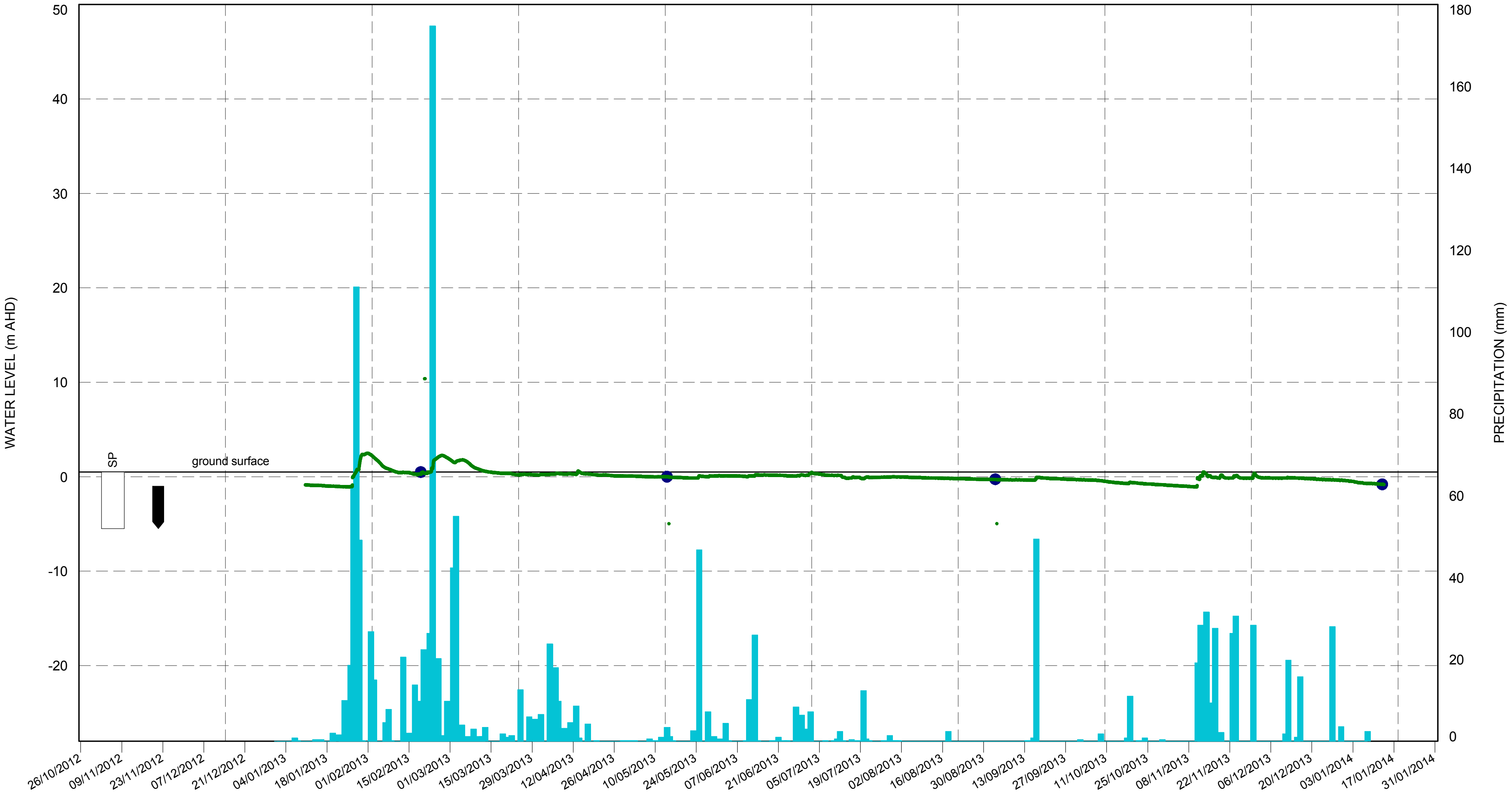
— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.82 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH	client:	Roads and Maritime Services
approved	AB	project:	Glenugie to Devils Pulpit Groundwater Monitoring
date	10/03/2014	title:	GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ59
scale	AS SHOWN	project no:	GEOTCOFH03059AA-AO
original size	A4	fig no:	FIGURE H63
		rev:	

coffey

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:07



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.50 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.50 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.04 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

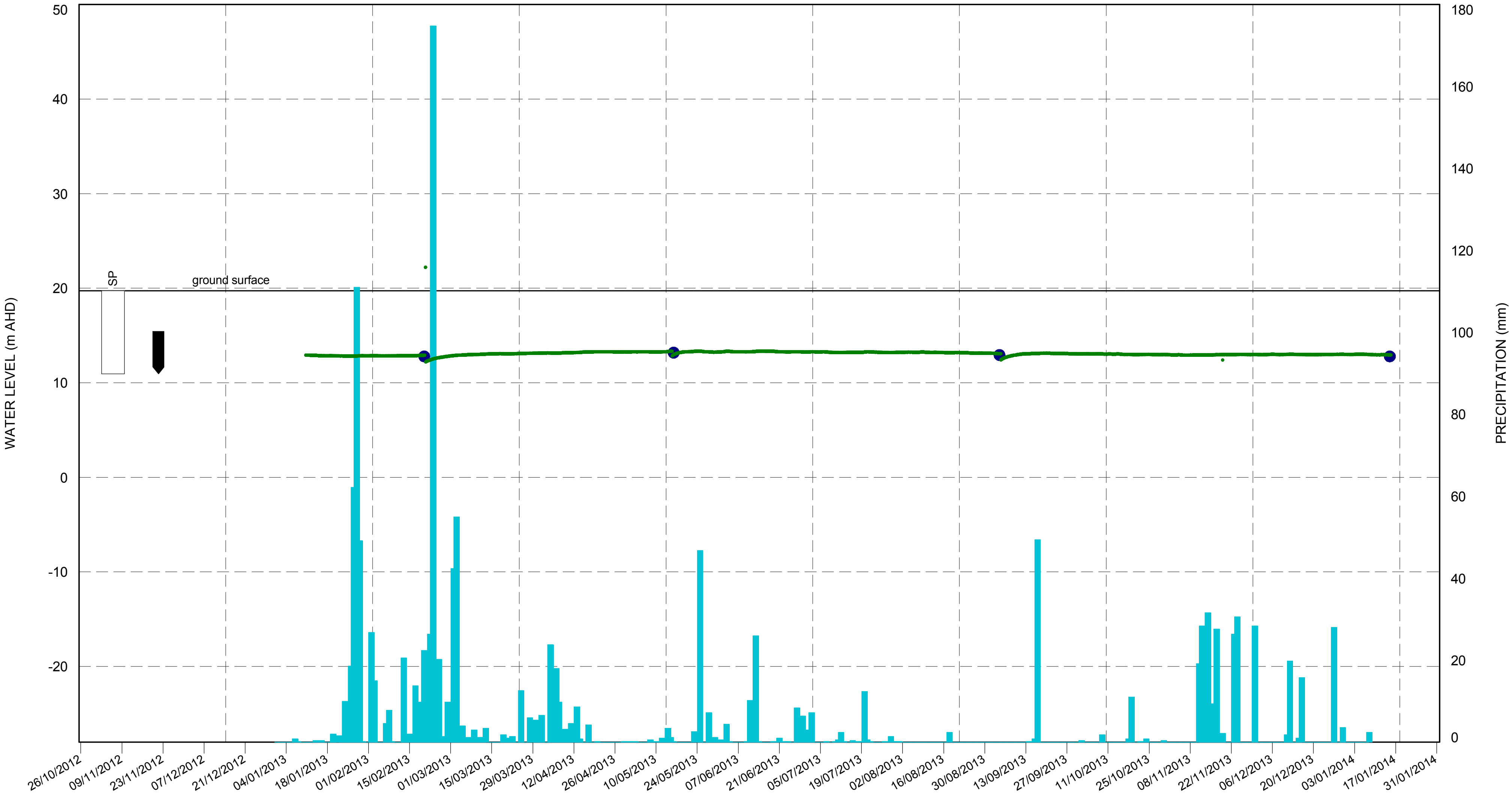
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ60**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H64** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:09

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 19.74 m AHD
Borehole Depth: 8.80 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 8.80 m bgl
RL of Tip: 10.94 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 8.80 m bgl
RL of Tip: 11.04 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

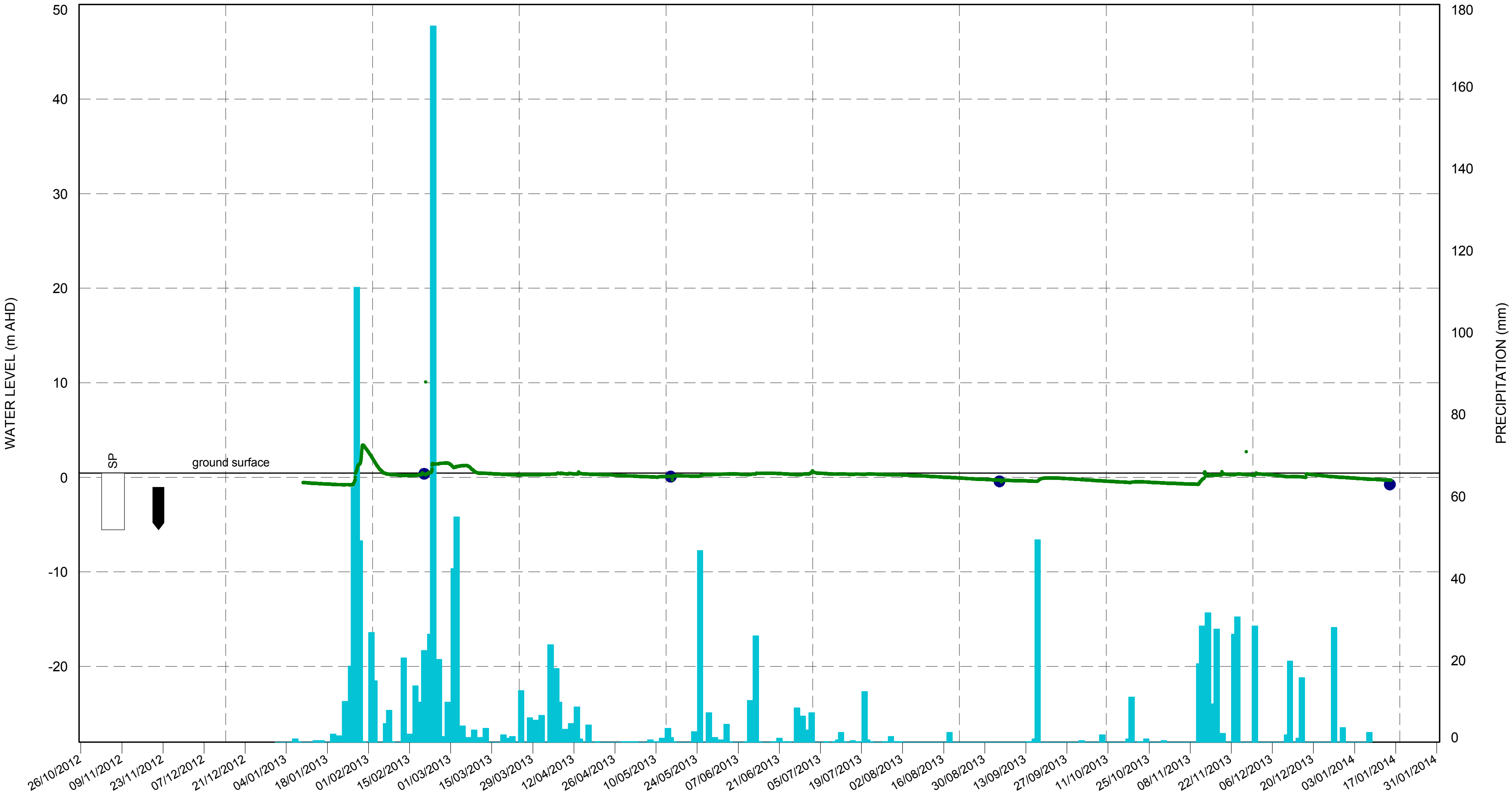
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ61**

project no: GEOTCOFH03059AA-AO	fig no: **FIGURE H65**	rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 0.46 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.54 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.04 m AHD

: Rainfall data is from
Bureau of Meteorology
website (www.bom.gov.au)
Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

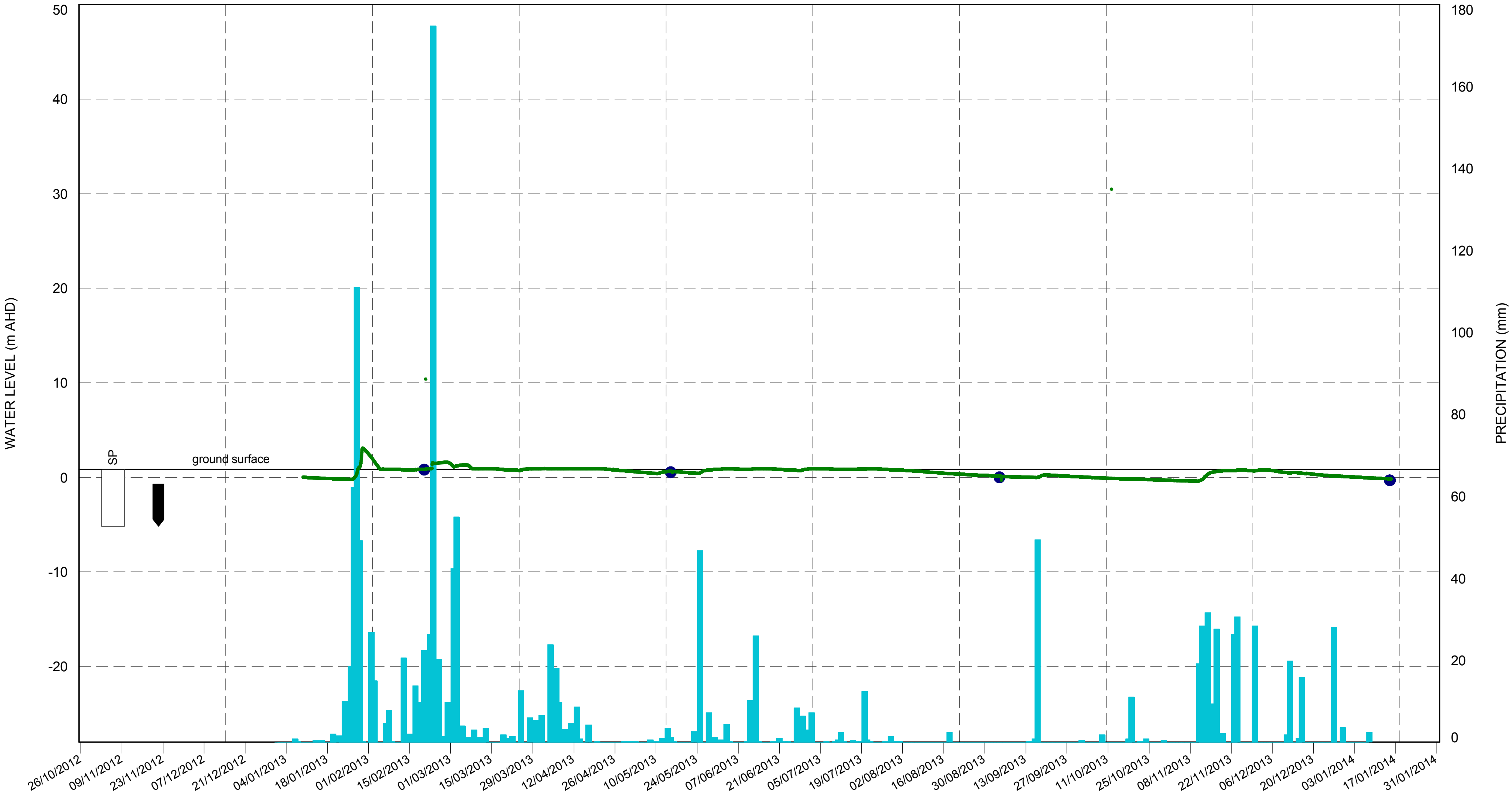
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME**
PZ62

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H66** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:11

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.82 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.18 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.59 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

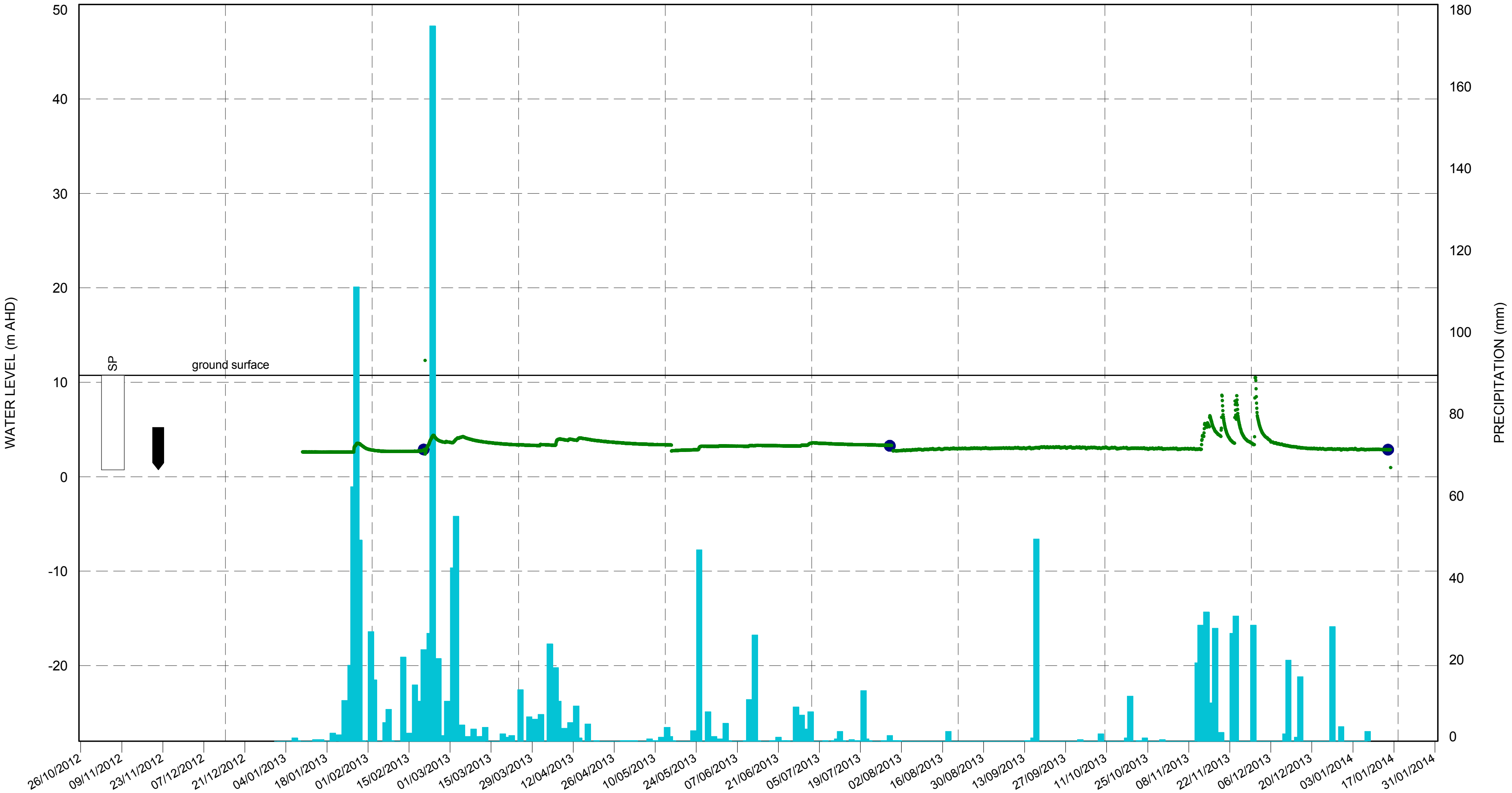
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ63**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H67** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:12

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 10.73 m AHD
Borehole Depth: 10.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 10.00 m bgl
RL of Tip: 0.73 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 10.00 m bgl
RL of Tip: 0.93 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

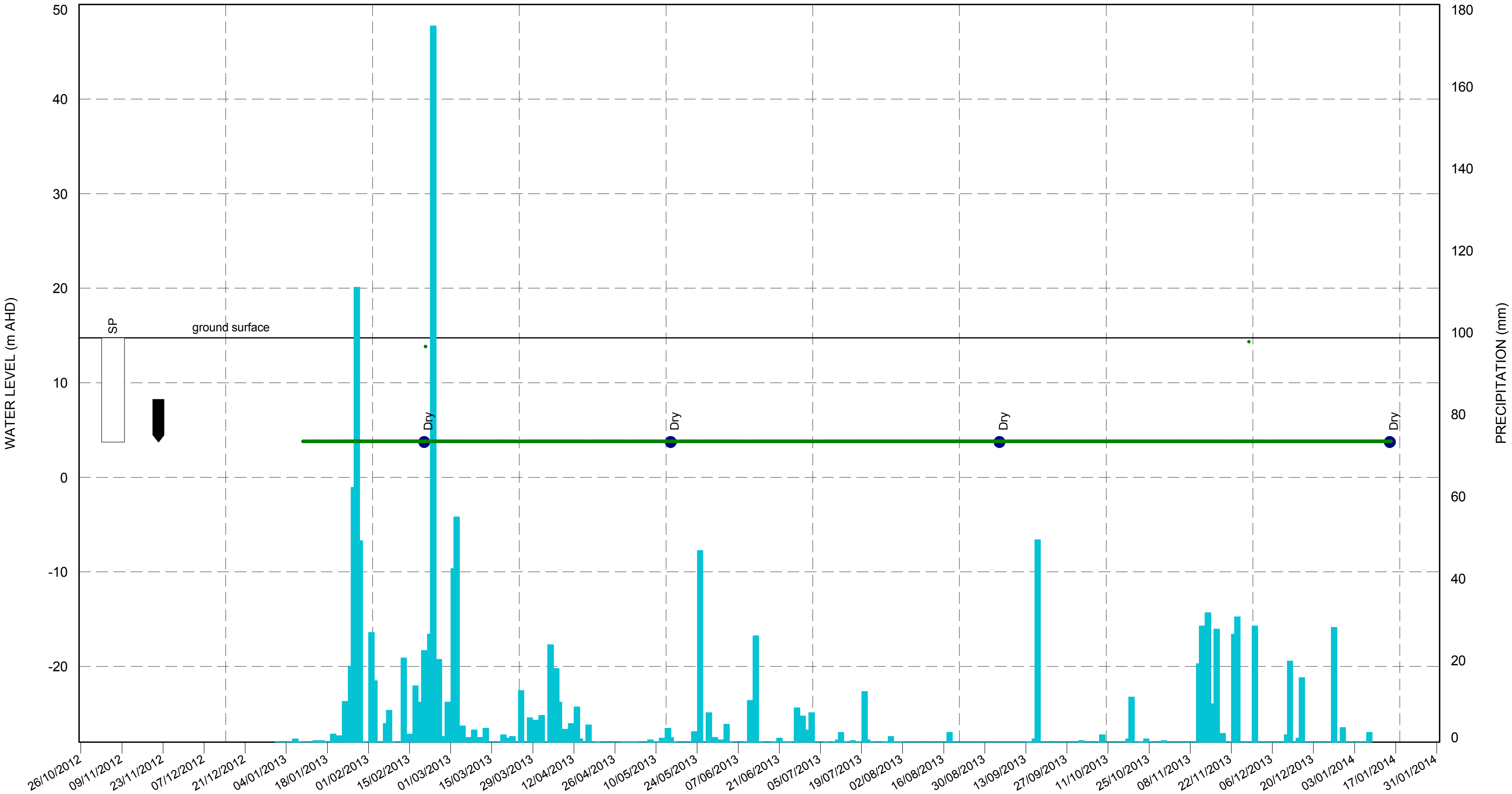
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ64**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H68** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:13

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 14.74 m AHD
Borehole Depth: 11.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 11.00 m bgl
RL of Tip: 3.74 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 11.00 m bgl
RL of Tip: 3.74 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

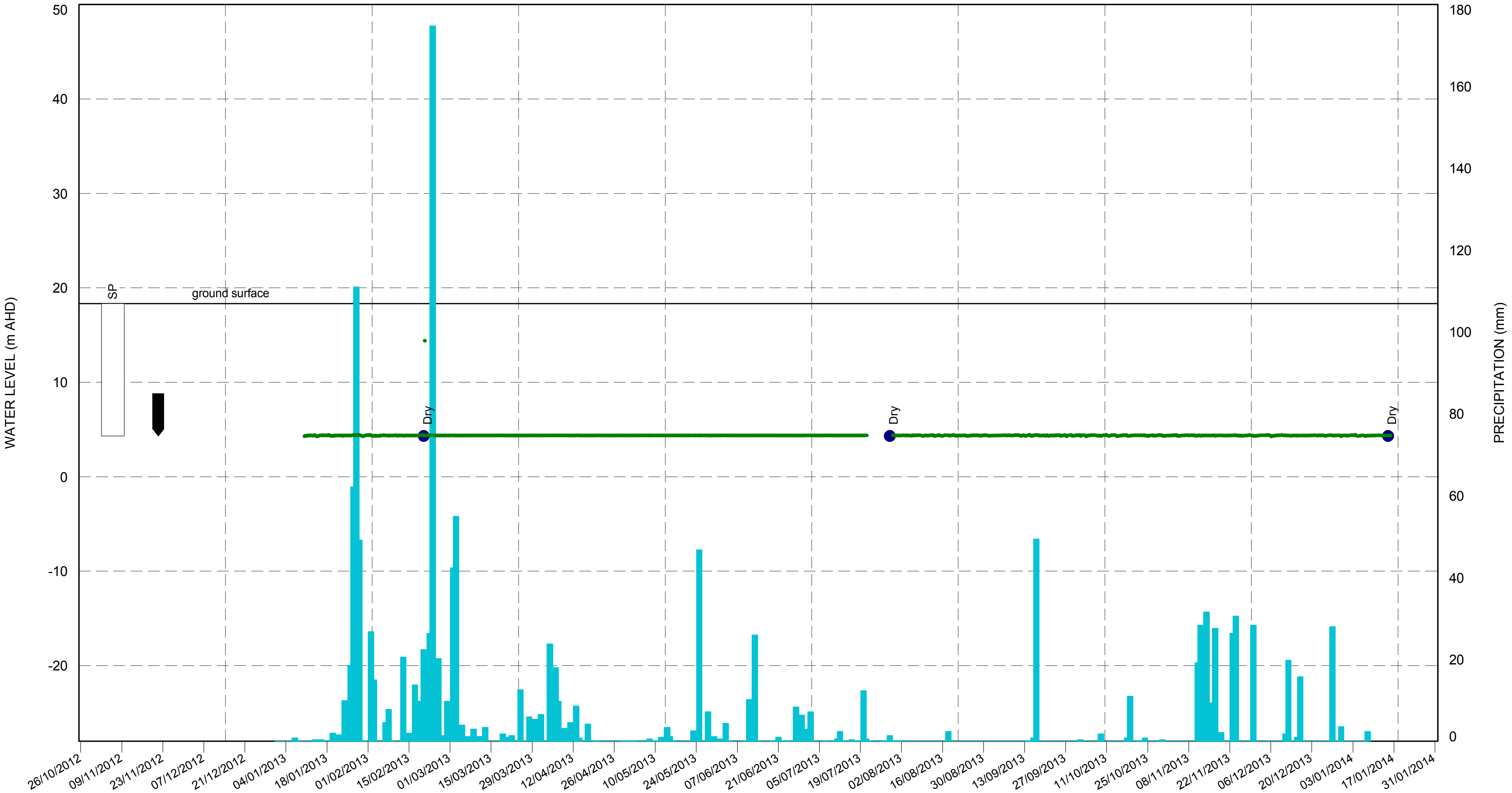
project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ65

project no: GEOTCOFH03059AA-AO

fig no: FIGURE H69

rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 18.32 m AHD
Borehole Depth: 14.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 4.32 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 4.32 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

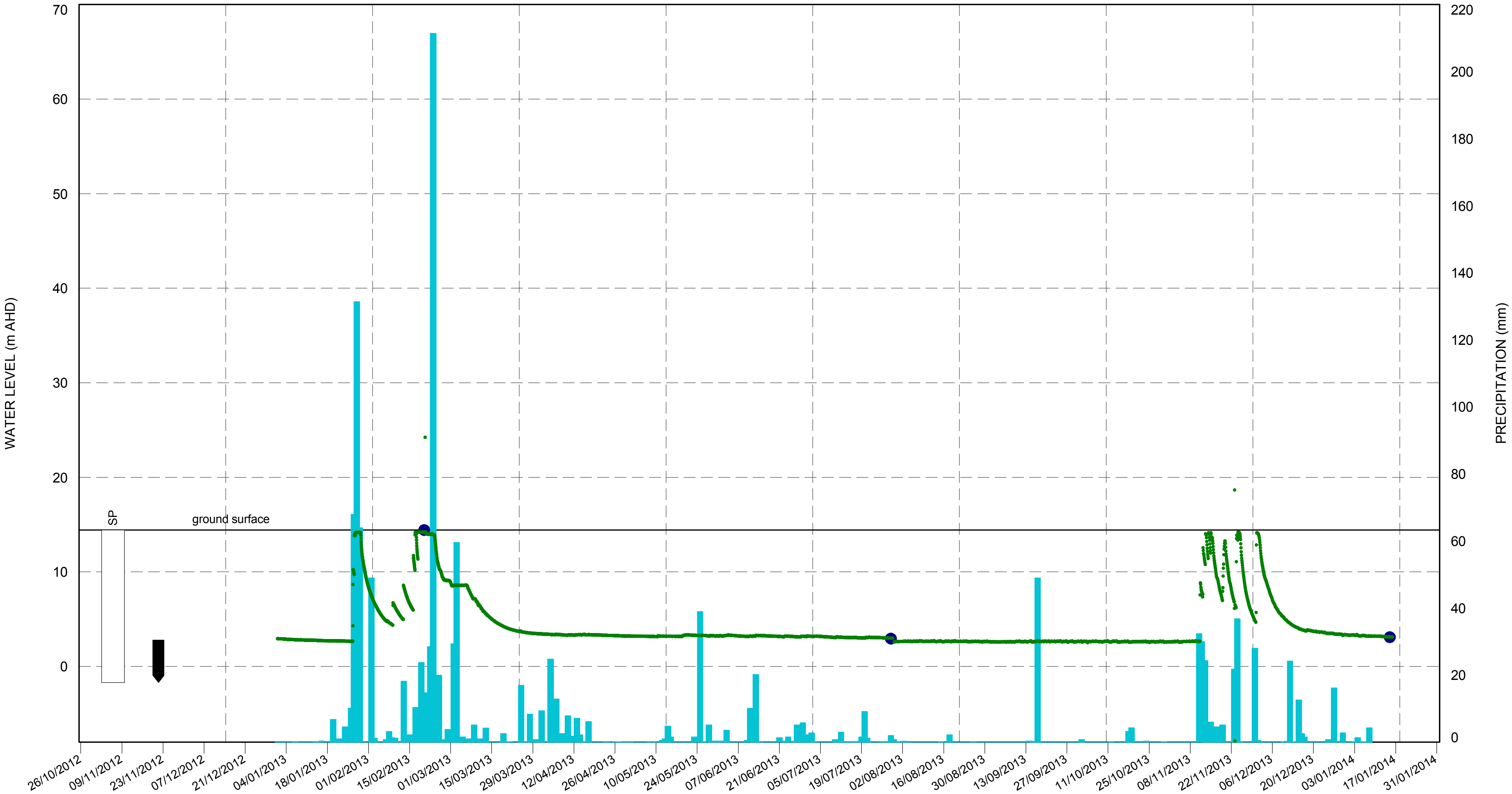
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ66**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H70** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

Surface RL: 14.43 m AHD
Borehole Depth: 16.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 16.12 m bgl
RL of Tip: -1.69 m AHD

—: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 16.12 m bgl
RL of Tip: 0.79 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

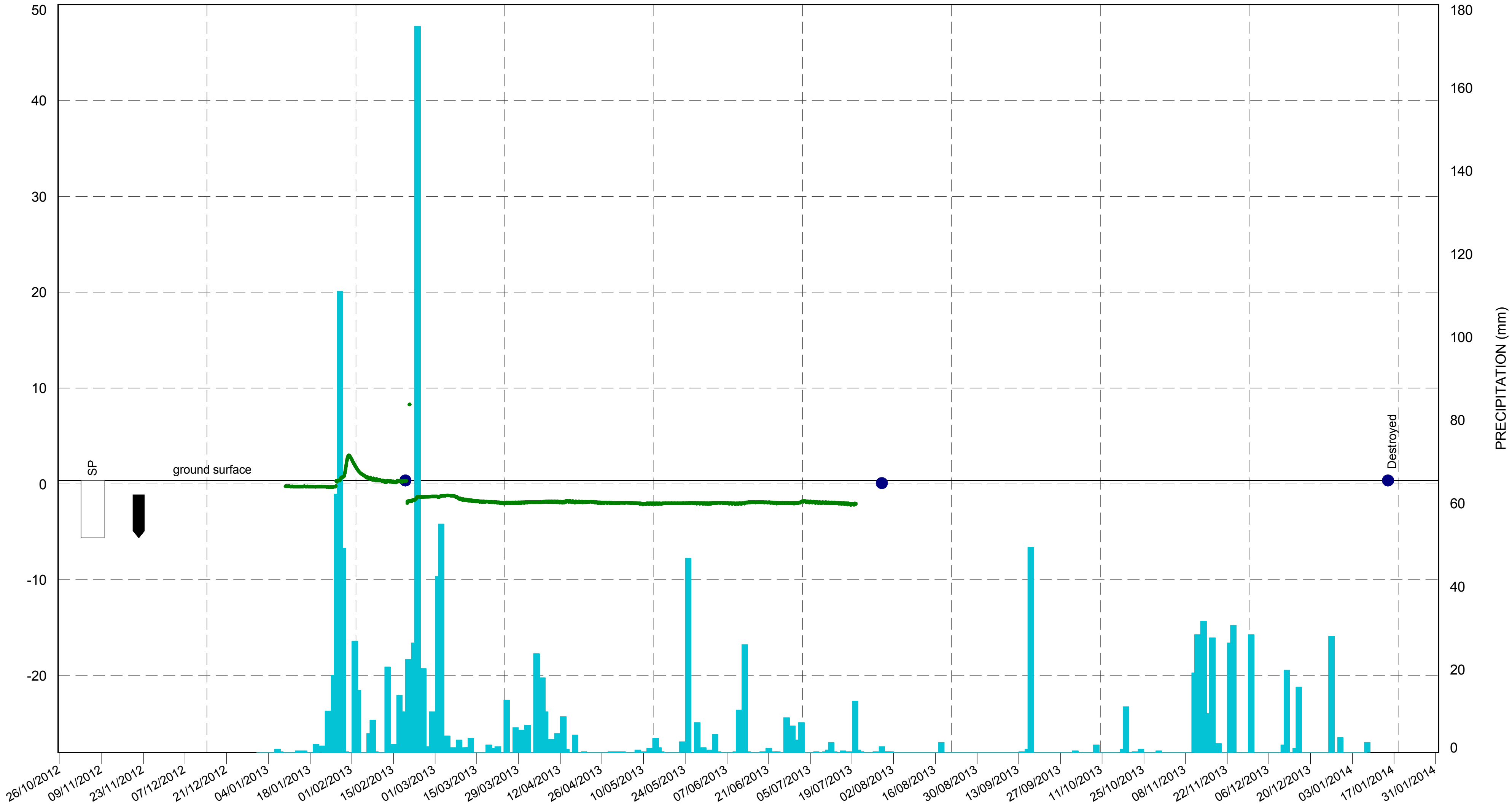
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1359**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H11** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:15

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.37 m AHD
Borehole Depth: 6.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.63 m AHD

━: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.17 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

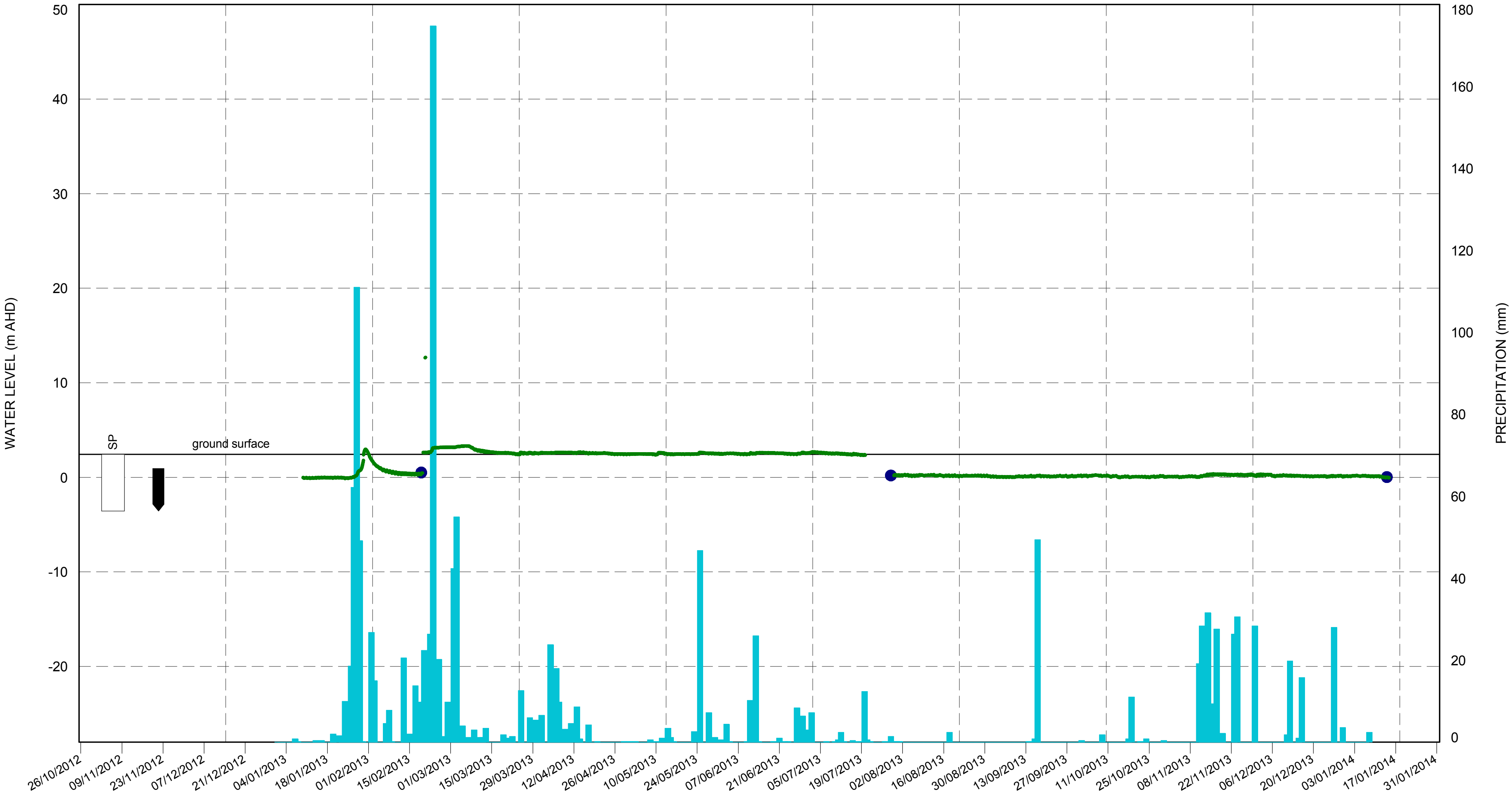
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ67**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H71** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 2.43 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.57 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.88 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

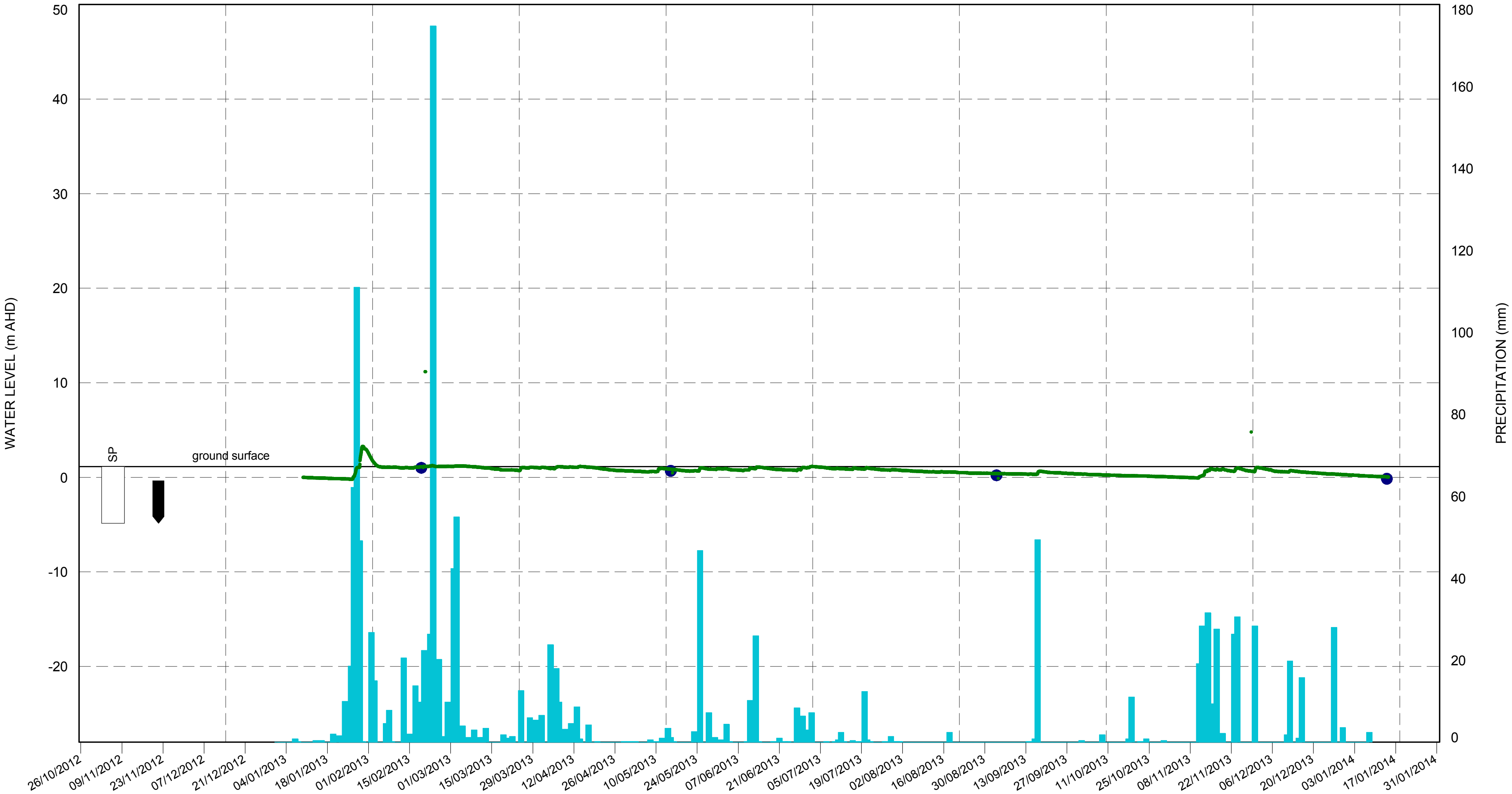
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ68

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H72 | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 1.14 m AHD
Borehole Depth: 6.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.86 m AHD

—: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.70 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

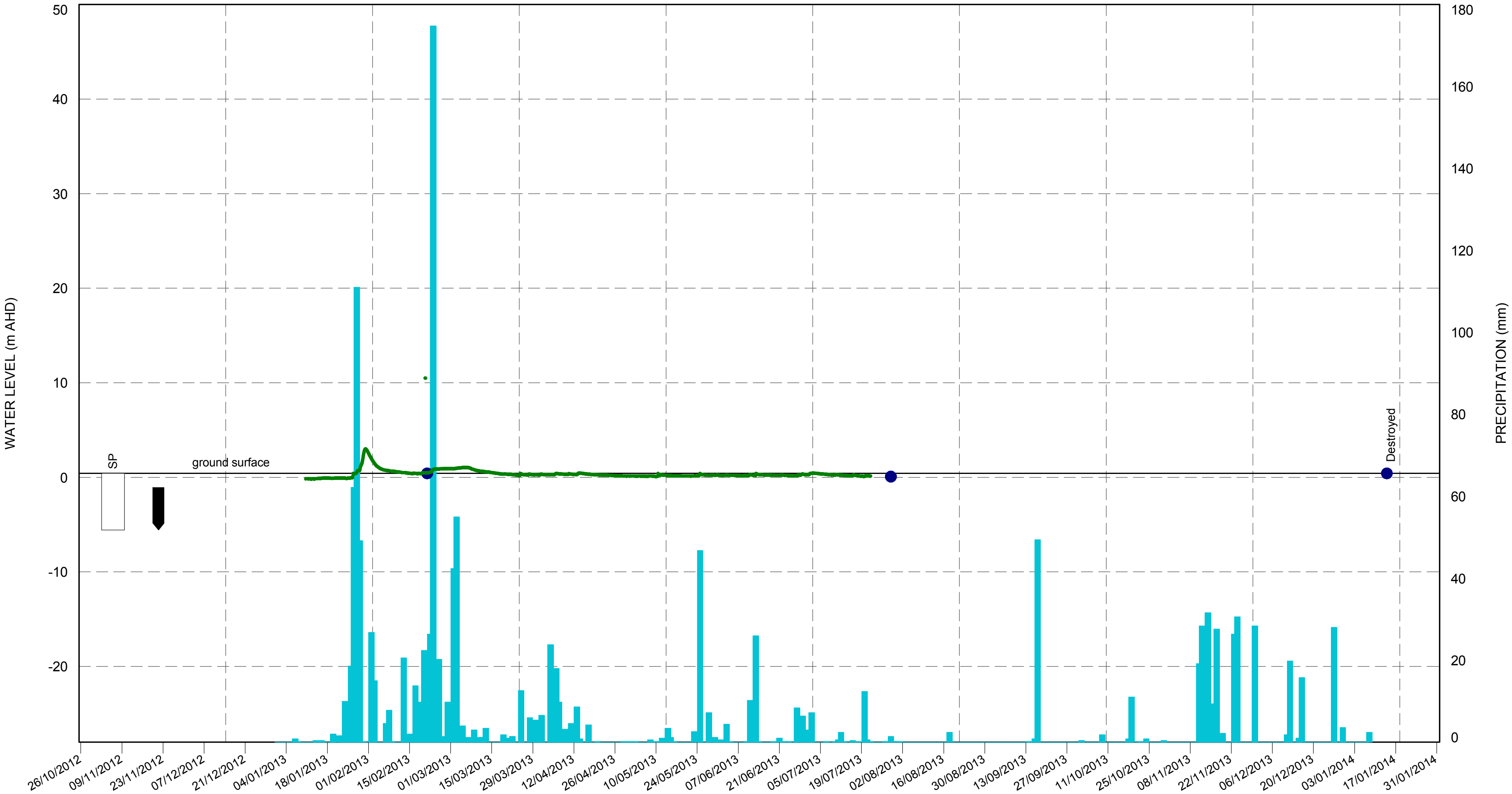
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ69**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H73** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:17



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.42 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.58 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.14 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ70

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H74 | rev:

Appendix D

Section 5 - Maclean to Iluka Road: Pre-Construction Monitoring Results

Section 5: Surface Water Monitoring Locations and associated Sensitive Receiving Environments

Surface Water Sample Locations / Waterway	*Waterway Description*	*Sensitive aquatic receiving environments and groundwater dependent ecosystems*
SW24 – Yaegl Wetland SW15 – Unnamed tributary of James Creek SW16 – Clarence River SW17 – Serpentine Channel SW18 – North Arm (Clarence River) SW19 – Mororo Creek (South)	Waterways within Section 5 are tidally influenced estuarine systems.	▪ SEPP 14 Coastal Wetland No. 220a is located to the south-east of the project and extends into Yaegl Nature Reserve. James Creek flows through the wetland into the nature reserve. ▪ SEPP 14 Coastal Wetland No. 153c is located about 400m west of the crossing of North Arm. ▪ All waterways are assessed to be key fish habitats with the potential for threatened aquatic species habitat to be present in the Clarence River.

Source: Table 1 in Coffey Geotechnics (2014c).

Section 5: Surface Water Monitoring – Overview of Results

Physical properties

Temperature generally exhibited a gradual increase generally from the low-teens (12-16°C) in winter up to the high 20s (26-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water creeks and tidal waterways.

Turbidity and total suspended solids (TSS) data varied greatly with some variable correlation between high TSS results and wet weather as would normally be anticipated. There was no clear correlation between turbidity and TSS.

Chemical properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. Median pH levels were generally in the range of 4.25 to 7.15.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 2.5 mg/L. Total Nitrogen values were generally less than 1.0 mg/L. However higher values were recorded at sample points; SW24, SW15 and SW17.

Heavy metals

Heavy metals were generally below detection limits.

Summary of Visual Observations and Sampling Results

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW24 Yaegl Wetland (Downstream) Ch. 84,400	▪ The small watercourse within Yaegl Wetland was ephemeral with the sample location varying due to the watercourse drying out. The sample location in the dry periods moved further north up into the water course. The water course was located to the north of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow to stagnant water observed. The water course was dry in October (Round 10). ▪ Water levels were high in February to April & July (Round 1-4 & 6b), normal in May (Round 5b) and the remaining months were observed as low water levels.	▪ O&G: <5-6.1mg/L ▪ TSS: <5-94mg/L ▪ TP: <0.01-0.42mg/L ▪ TN: 0.5-3.6mg/L ▪ DO: 0.63-8.66mg/L ▪ EC: 249-2016µS/cm ▪ pH: 3.11-6.12 ▪ Temp: 12.4-28.4ºC ▪ NTU: 6.51-59.7
SW15 Unnamed tributary of James Creek (Downstream) Ch. 85,200	▪ Unnamed tributary of James Creek was dry several times during the monitoring program and the sample location varied with the sampling location moving further north up the water course during the periods of dry weather. The water course was located to the north of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow to stagnant water observed. The water course was dry from August to October (Round 8 to 10) & December (Round 12). ▪ Water levels were high in February to April (Round 1-4); normal in July (Round 6) and the remaining months were observed as low water levels or dry.	▪ O&G: <5-6mg/L ▪ TSS: 5-430mg/L ▪ TP: <0.02-0.8mg/L ▪ TN: 0.5-18mg/L ▪ DO: 2.5-8.64mg/L ▪ EC: 10.07µS/cm-5.44mS/cm ▪ pH: 3.21-6.68 ▪ Temp: 11.7-30.9ºC ▪ NTU: 9.36-648
SW16 Clarence River (Tidal) Ch. 86,300	▪ Clarence River is a large tidal estuary system and this site is where the proposed G2DP highway alignment will passes over the river. The sample location was on the southern bank of the River. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. Moderate flows in May (Round 5). ▪ Water levels were high in February and December (Round 2 & 12) and the remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: 7-1100mg/L ▪ TP: <0.01-0.28mg/L ▪ TN: <0.2-0.96mg/L ▪ DO: 3.41-10.05mg/L ▪ EC: 85.4µS/cm-26.2mS/cm ▪ pH: 6.44-7.42 ▪ Temp: 15.7-25.9ºC ▪ NTU: 6.55-544

Site Identifier/Waterway	***Summary of Visual Observations***	***Overview of Water Quality Sampling Results***
SW17 Serpentine Channel (Tidal) Ch. 89,400	▪ Serpentine Channel is a tributary of the Clarence River and this site is east of where the proposed G2DP highway alignment passes over. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ No variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. ▪ Water levels were high in February (Round 2) and the remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: 12-62mg/L ▪ TP: 0.03-0.35mg/L ▪ TN: 0.32-5.3mg/L ▪ DO: 1.9-9.44mg/L ▪ EC: 141-µS/cm-30.3mS/cm ▪ pH: 6.44-7.58 ▪ Temp: 15.4-28.5ºC ▪ NTU: 7.26-166
SW18 North Arm of the Clarence River (Tidal) Ch. 94,000	▪ North Arm Clarence is a large tributary of the Clarence River where the proposed G2DP highway alignment passes over. The sample location was on the northern banks of the River ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ No variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. ▪ Water levels were high in February (Round 2) the remaining months were observed as normal water levels.	▪ O&G: <5-11mg/L ▪ TSS: <5-190mg/L ▪ TP: <0.01-0.07mg/L ▪ TN: <0.2-0.8mg/L ▪ DO: 3.73-26.3mg/L ▪ EC: 136.4µS/cm-32.1mS/cm ▪ pH: 6.6-7.54 ▪ Temp: 16.0-28.6ºC ▪ NTU: 3.11-110
SW19 Mororo Creek (Downstream) Ch. 95,1000	▪ Mororo Creek is small Creek system, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was minimal variation in flow velocity during the monitoring program with generally slow flows to stagnant water observed. There were moderate flows observed during Round 6b (July). ▪ Water levels were high in February & July (Round 2 & 6b), the Creek was low in Rounds 5, 6 & 7 (May, June & July). The remaining months were observed as normal water levels.	▪ O&G: <5-7.2mg/L ▪ TSS: <5-26mg/L ▪ TP: <0.01-0.22mg/L ▪ TN: 0.421.3mg/L ▪ DO: 2.81-9.23mg/L ▪ EC: 229µS/cm-23.6mS/cm ▪ pH: 5.46-6.93 ▪ Temp: 14.1-27.6ºC ▪ NTU: 4.32-57.4

Note: * Ch. = Highway Chainage

Section 5: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 5							
SW24 (SW5-01 and SW5-02)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.76	0.96	2.5	6.1	2.5	2.50	-	
Suspended Solids	mg/l	24.00	27.59	2.5	94	11	42.00	-	
Total Phosphorus as P	mg/l	0.15	0.13	0.005	0.42	0.14	0.25	-	
Total Nitrogen as N	mg/l	1.28	0.83	0.5	3.6	0.95	1.78	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.24	2.62	0.63	8.66	5.145	7.84	3.36	
Conductivity	µs/cm	1071.93	536.21	249	2016	984	1472.60	659.60	
pH		4.67	1.17	3.11	6.21	4.25	5.98	3.65	
Temperature	$^{\circ}C$	20.43	4.59	12.4	28.4	20.75	23.94	-	
Turbidity	NTU	21.84	19.26	6.51	59.7	11.45	40.12	-	
SW15 (SW5-03 and SW5-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.79	1.01	2.5	6	2.5	2.50	-	
Suspended Solids	mg/l	89.08	120.94	5	430	37.5	120.00	-	
Total Phosphorus as P	mg/l	0.17	0.21	0.01	0.8	0.115	0.15	-	
Total Nitrogen as N	mg/l	7.24	5.83	0.5	18	6	12.60	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.93	2.17	2.5	8.64	4.67	6.99	2.70	
Conductivity	µs/cm	800.71	964.91	10.07	2300	336	1443.20	104.81	
pH		5.81	1.16	3.21	6.7	6.36	6.50	5.17	
Temperature	$^{\circ}C$	20.68	6.41	11.7	30.9	19.65	26.74	-	
Turbidity	NTU	156.02	224.20	9.36	648	31.6	259.60	-	
SW16 (SW5-05 and SW5-06									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	120.60	276.66	7	1100	25	90.40	-	
Total Phosphorus as P	mg/l	0.18	0.44	0.005	1.75	0.04	0.11	-	
Total Nitrogen as N	mg/l	0.48	0.23	0.1	0.96	0.45	0.57	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	8.14	1.63	3.41	10.05	8.46	9.22	7.43	
Conductivity	µs/cm	1394.10	1361.14	85.4	2760	1365.5	2520.00	256.76	
pH		6.93	0.30	6.44	7.6	6.92	7.13	6.72	
Temperature	$^{\circ}C$	21.30	3.86	15.7	25.9	22.6	24.86	-	
Turbidity	NTU	73.88	141.07	6.55	544	17.9	92.32	-	
SW17 (SW5-07 and SW5-08)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	27.60	13.83	12	62	25	33.60	-	
Total Phosphorus as P	mg/l	0.21	0.44	0.03	1.75	0.05	0.20	-	
Total Nitrogen as N	mg/l	1.23	1.23	0.32	5.3	1.1	1.62	-	

	Units	SECTION 5							
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.78	2.17	1.9	9.44	6.81	8.83	5.32	
Conductivity	µs/cm	3934.67	7358.67	141	18890	960.5	2146.00	510.00	
pH		7.03	0.33	6.44	7.58	7.02	7.34	6.81	
Temperature	○C	21.91	4.53	15.4	28.5	22	26.30	-	
Turbidity	NTU	28.87	40.73	6.38	166	12.6	38.12	-	
SW18 (SW5-09 and SW5-10)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	3.07	2.19	2.5	11	2.5	2.50	-	
Suspended Solids	mg/l	27.42	46.51	2.5	190	13	28.20	-	
Total Phosphorus as P	mg/l	0.15	0.44	0.005	1.75	0.03	0.07	-	
Total Nitrogen as N	mg/l	0.49	0.22	0.1	0.8	0.42	0.76	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	9.31	4.91	3.73	26.3	8.57	9.11	7.82	
Conductivity	µs/cm	4754.88	9809.49	136.4	22300	457	4929.60	262.48	
pH		7.10	0.27	6.6	7.54	7.15	7.30	6.89	
Temperature	○C	22.75	4.06	16	28.6	24.8	26.06	-	
Turbidity	NTU	19.37	28.44	3.11	110	8.66	20.64	-	
SW19 (SW5-11)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.81	1.21	2.5	7.2	2.5	2.50	-	
Suspended Solids	mg/l	12.30	8.03	2.5	26	13	19.40	-	
Total Phosphorus as P	mg/l	0.17	0.44	0.005	1.75	0.04	0.10	-	
Total Nitrogen as N	mg/l	0.87	0.24	0.42	1.3	0.9	1.02	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.26	2.18	2.81	9.23	6.52	8.60	4.54	
Conductivity	µs/cm	973.23	1350.16	134.9	4860	551	1091.00	229.00	
pH		6.33	0.38	5.46	6.93	6.48	6.61	5.98	
Temperature	○C	21.08	4.45	14.1	27.6	21.8	24.92	-	
Turbidity	NTU	16.52	15.32	4.32	57.4	10.8	27.66	-	

Section 5: Groundwater Monitoring – Water Quality Overview

Electrical Conductivity

Values are indicative of freshwater to brackish / saline groundwater conditions with average salinity values ranging between 200 µS/cm (PZ21) to 9,320 µS/cm (PZ09). Generally the 12 well locations with shallower water levels (<5.0m below ground level) found within areas of fill or the bridge locations near Edwards Creek of the south bank of the Clarence River showed larger standard deviations than wells with standing water levels at greater depths located in cuts. The observed variation may be due to these locations proximity to tidal waterways and the influence of wet weather events on groundwater conductivity.

pH

pH, of groundwater in Section 4 show average values ranging from pH 5.68 (PZ55) to pH 10.29 (BH1206). The majority, 19 of 20 locations, had an average pH >6 which indicates a slightly acidic to neutral pH in groundwater throughout Section 4. Little variation occurs in pH with 4 of the 20 wells reporting a standard deviation value >1 pH unit.

Temperature

The average temperature values for the monitoring locations in Section 4 ranged between 20.8◦C to 23.4◦C. The variation in groundwater average temperature values throughout Section 4 is likely to be attributable to seasonal temperature changes and the variable depth of groundwater from the ground surface.

Cut/Fill Number	***Bor'hole Identif'r***	**Electrical Conductivity (µS/cm)**				**pH**				**Temp. (◦C)**
		Med.*	***SD*****	***P80***	***P20***	***Med.****	***SD*****	***P80***	***P20***	***Med.****
Fill 5-3	PZ71	18425	6720	21280	12662	7.30	0.09	7.38	7.23	21.60
	PZ72	3393	4245	7226	400	7.47	0.47	7.83	7.04	22.30
Serp'ntine Channel Bridge	GBH110	26850	2766	28480	24300	7.20	0.15	7.33	7.14	23.10
	PZ73	5040	434	5362	4798	7.34	0.69	7.90	7.23	21.55
Fill 5-5	PZ74	614	2220	2521	236	6.78	0.23	6.97	6.61	22.70
	PZ75	4023	5218	8782	371	7.57	0.66	8.04	7.27	22.30

Note: * Med. = Median
** DS = Standard Deviation

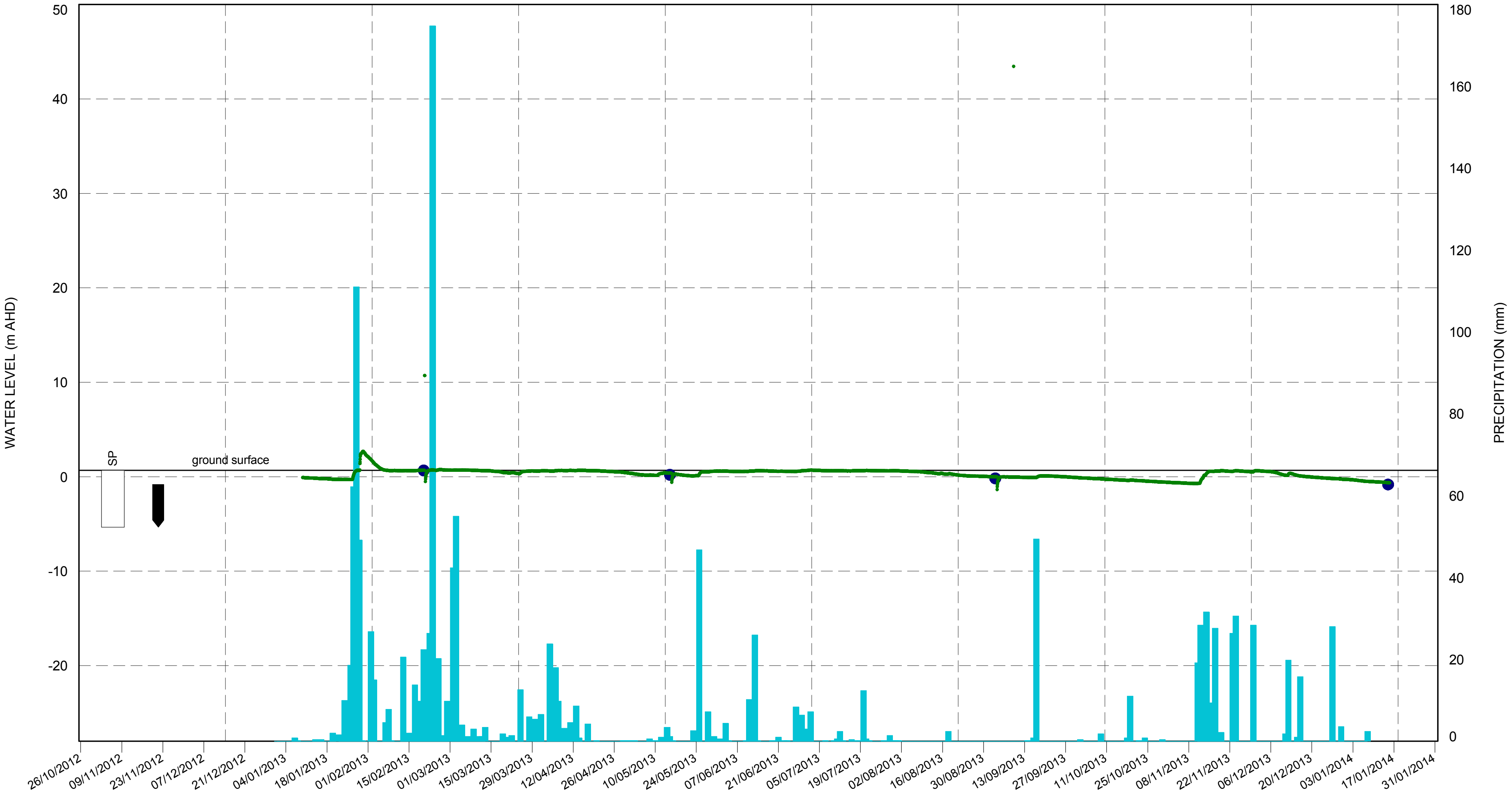
Section 5: Groundwater Monitoring – Levels

The typical standing water levels in Section 4 averaged between 0.07m (PZ67) and 22.78m (BH1251) below ground surface. In general, the SWLs observed in areas of proposed fill or bridges in Section 4 were noted to be close to the ground surface (<2m bgs) indicating shallow groundwater. The long term monitoring data indicates that the groundwater levels throughout much of Section 4 are influenced by large rainfall events (e.g. over 100mm rainfall event in January 2013). It should be noted the SWLs are relative to the topography of the monitoring location.

Summary of Groundwater Level Monitoring – Section 5 G2DP Upgrade

Cut/Fill Number	***Monitoring Location***	***Borehole Depth***	***Typical SWL (m below ground level)***		
			AVG	***MED***	***SD***
Fill 5-3	PZ71	6	0.70	0.65	0.63
	PZ72	6	1.37	1.42	0.49
Serpentine Channel Bridge	GBH110	41	4.11	4.11	0.16
	PZ73	6	1.09	1.20	0.55
Fill 5-5	PZ74	6	0.67	0.79	0.37
	PZ75	6	0.75	0.82	0.50

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:20



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.67 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.33 m AHD

━ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.08 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

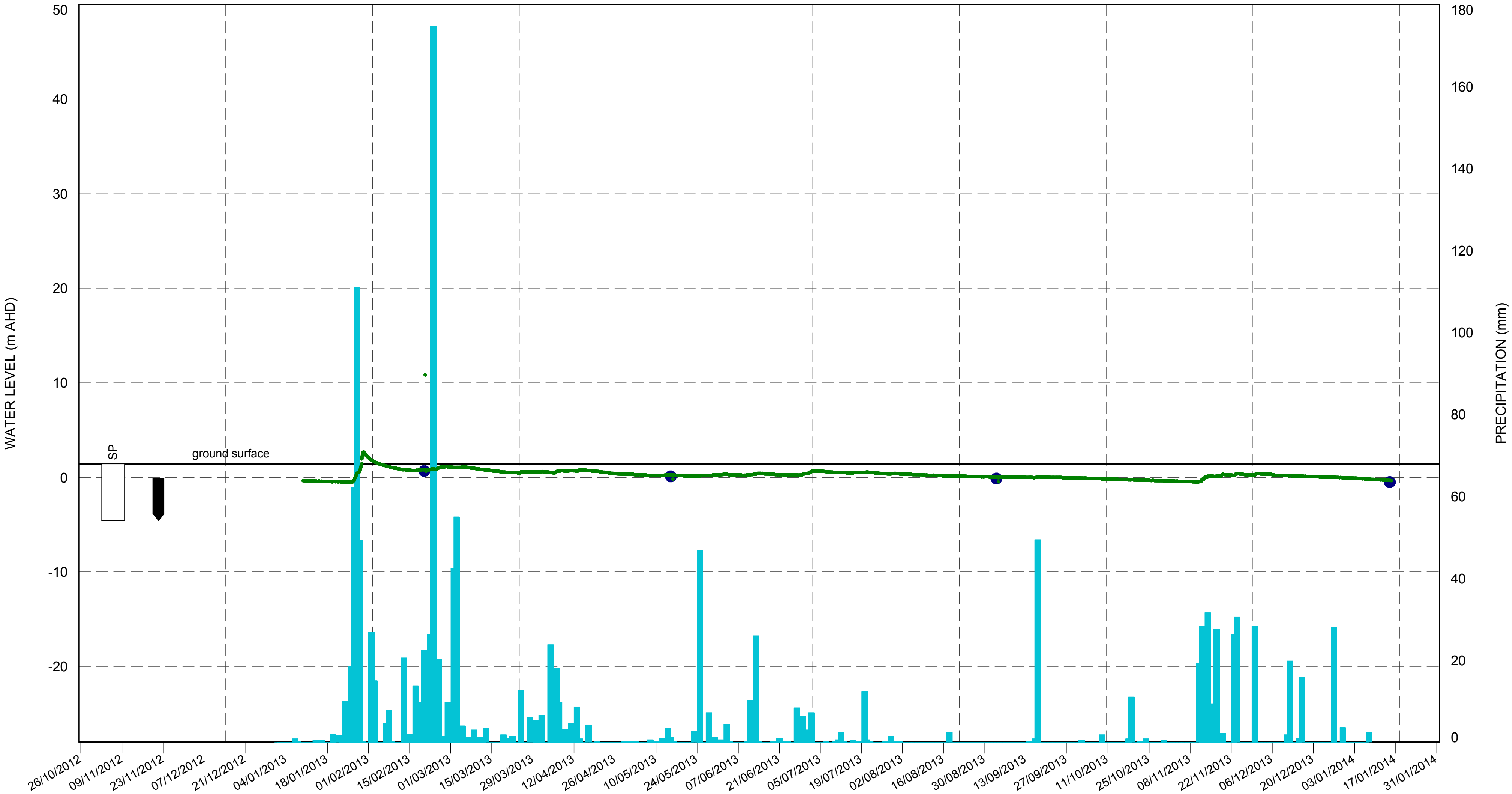
project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ71**

project no: GEOTCOFH03059AA-AO

fig no: **FIGURE H75**

rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 1.41 m AHD
Borehole Depth: 6.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.59 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.41 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ72

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H76 | rev:

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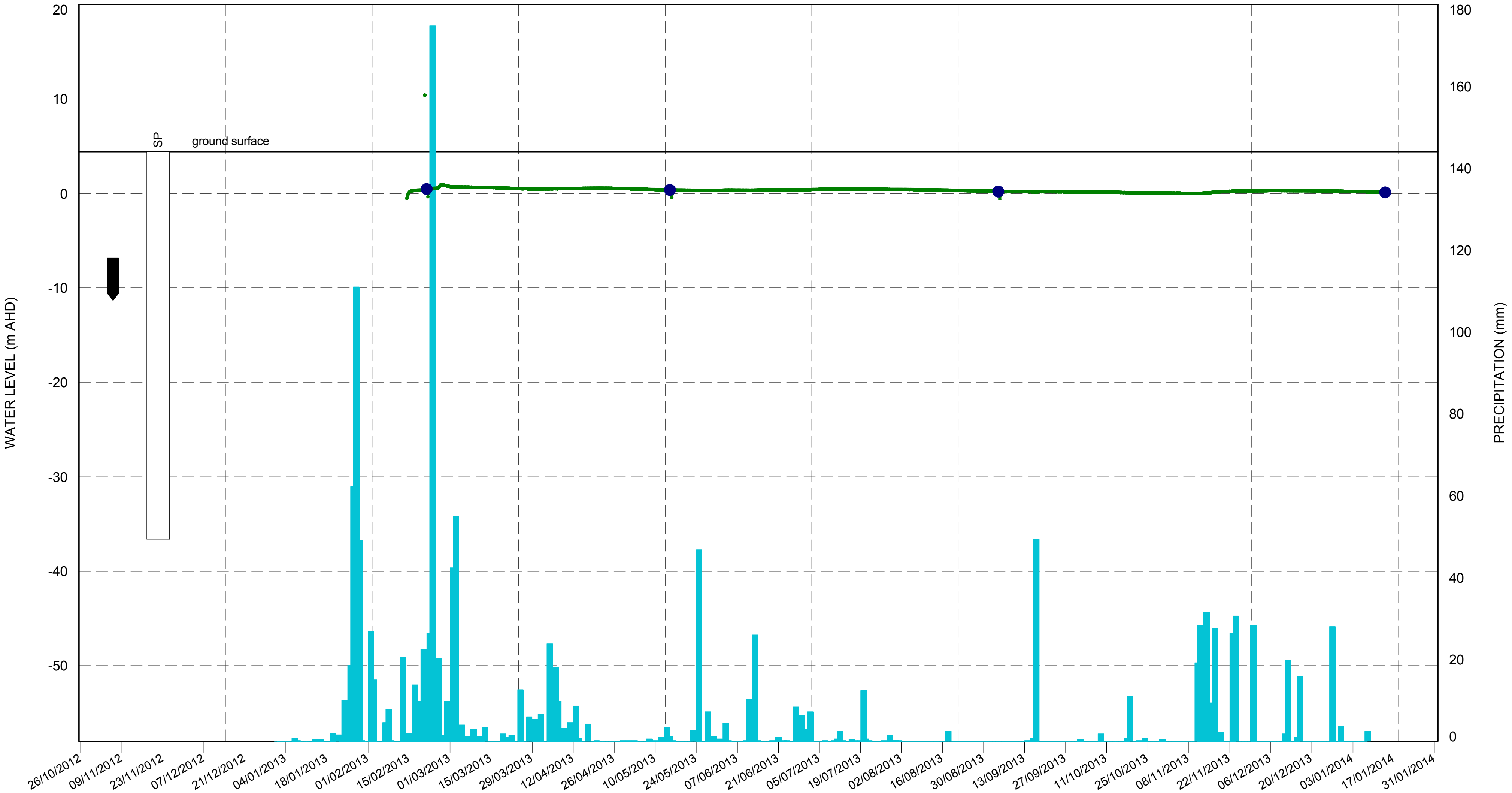


Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 4.40 m AHD
Borehole Depth: 41.76 m

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.73 m bgl
RL of Tip: -11.33 m AHD

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 41.00 m bgl
RL of Tip: -36.60 m AHD

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

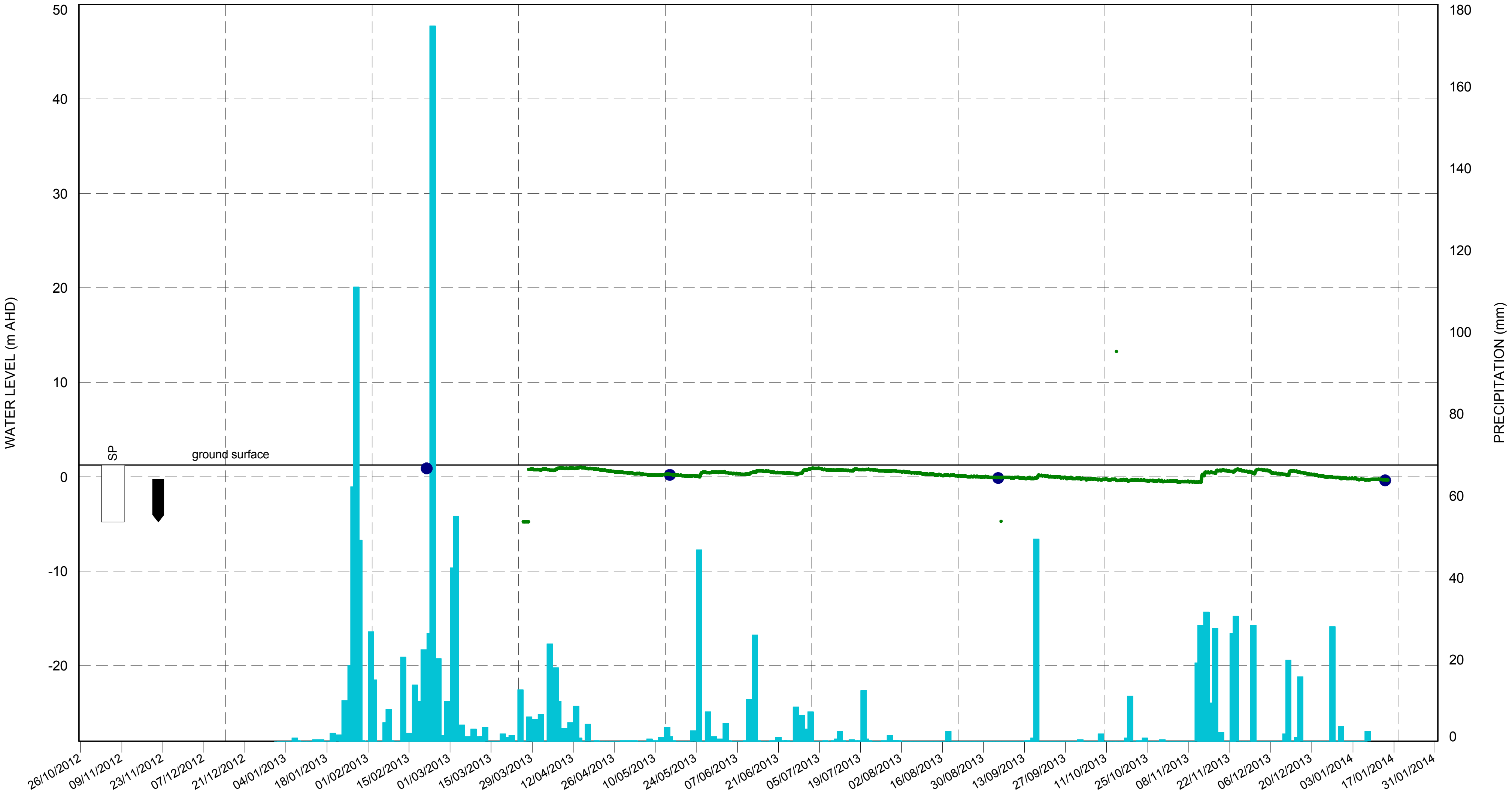
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME GBH110**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H12** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 1.23 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.77 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.81 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ73**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H77** | rev:

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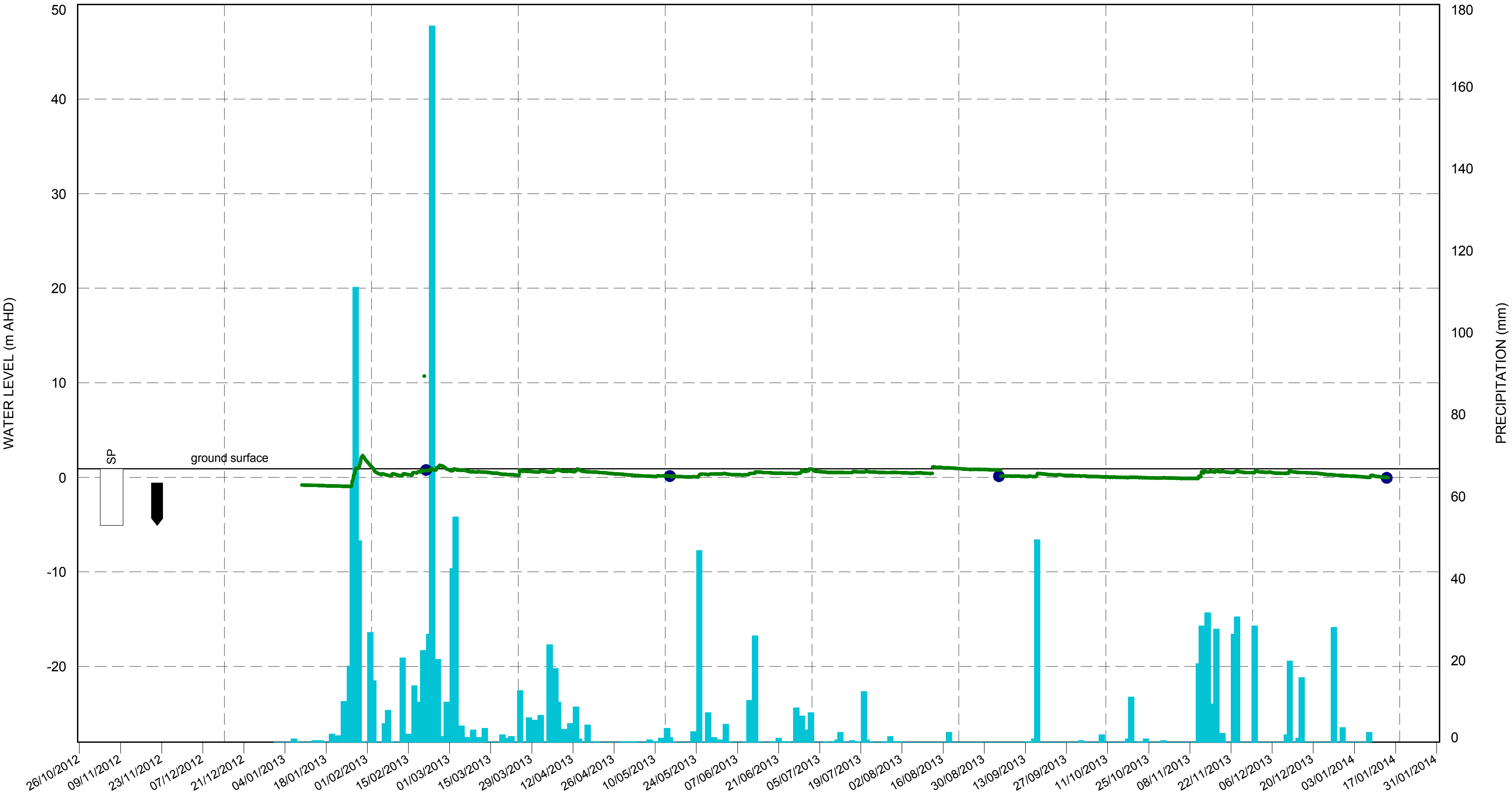


Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.92 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.08 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.38 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

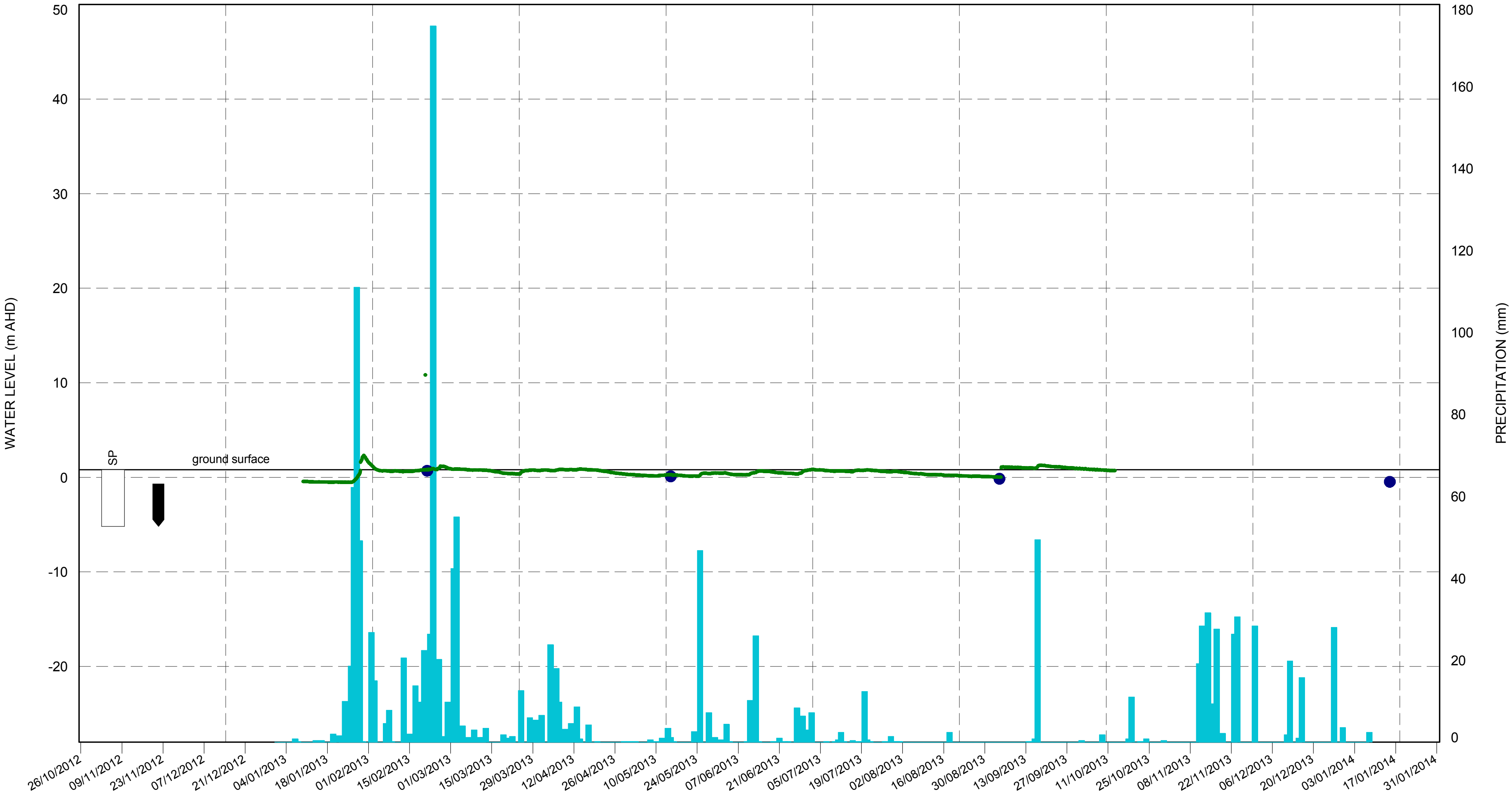
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ74**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H78** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:25

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.80 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.20 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.02 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ75**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H78** | rev:

Appendix E

Section 6 - Iluka Road to Devils Pulpit: Pre-Construction Monitoring Results

Section 6: Surface Water Monitoring Locations and associated Sensitive Receiving Environments

Surface Water Sample Locations / Waterway	*Waterway Description*	*Sensitive aquatic receiving environments and groundwater dependent ecosystems*
SW20 – Mororo Creek (North) SW21 – Tabbimobile Creek SW25 – Tabbimoble Overflow	Mororo Creek is ephemeral freshwater waterway at the Pacific Highway and may only flow after wet weather. Tabbimobile Creek is assessed to be estuarine downstream of the weir and freshwater upstream.	▪ SEPP 14 Coastal Wetland No. 153a is located on Tabbimobile Creek about 1km to the east of the project. ▪ SEPP 14 Coastal Wetland No. 153 is located 4.5km to the east of the project, within Bundjalung National Park and Devils Pulpit State Forest, and extends between North Arm in the south and the Evans River in the north. All waterways are assessed to be key fish habitats with the potential for threatened aquatic species habitat.

Source: Table 1 in Coffey Geotechnics (2014c).

Section 6: Surface Water Monitoring – Overview of Results

Physical properties

Temperature generally exhibited a gradual increase generally from the low-teens (11-14°C) in winter up to the mid-20s (25-26°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water creeks.

Turbidity and total suspended solids (TSS) data varied greatly with some correlation between high TSS results and wet weather as would normally be anticipated. There was some correlation evident between turbidity and TSS.

Chemical properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. Median pH levels were generally in the range of 6.37 to 6.57.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 0.5 mg/L. Total Nitrogen values were found to be in the range of 0.13 to 2.4 mg/L.

Heavy metals

Heavy metals were generally below detection limits.

Summary of Visual Observations and Sampling Results

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW20 Mororo Creek (Downstream) Ch. 96,650	▪ Mororo Creek at this location is small Creek system, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow to stagnant flows observed. Moderate flows during the wet weather event in July (Round 6b). ▪ Water levels were high in February, July & November (Round 2, 6b, 11a & 11b) and low in May, June & August (Round 5, 6 & 8). The remaining months observed normal water levels.	▪ O&G: <5-6.6mg/L ▪ TSS: <5-82mg/L ▪ TP: <0.02-0.11mg/L ▪ TN: 0.3-2.4mg/L ▪ DO: 3.18-8.72mg/L ▪ EC: 231-1619µS/cm ▪ pH: 3.74-7.02 ▪ Temp: 13.7-25.1ºC ▪ NTU: 3.67-154
SW21 Tabbimoble Creek (Upstream) Ch. 101,600	▪ Tabbimoble Creek was a permanent water course, within rural bushland (Crown Land), up gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity throughout the monitoring program with generally slow to stagnant flows observed. Moderate flows during the wet weather in February, April, July & November (Round 2, 4, 6b, 11a & 11b). ▪ Water levels were high in February & March (Round 2 & 6b) and low in August to October (Round 8 - 10). The remaining months were observed as normal water levels.	▪ O&G: <5-5mg/L ▪ TSS: <5-50mg/L ▪ TP: <0.01-0.05mg/L ▪ TN: 0.13-0.9mg/L ▪ DO: 3.41-10.30mg/L ▪ EC: 86.6-543µS/cm ▪ pH: 5.93-7.33 ▪ Temp: 12.7-25.6ºC ▪ NTU: 11-47.9
SW25 Tabbimoble Overflow (Downstream) Ch. 102,900	▪ Tabbimoble Overflow was a permanent water course, within bushland (private property), down gradient of the proposed G2DP highway alignment. ▪ No visual signs of sheens, odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow to stagnant flows observed. Moderate flows were observed during the wet weather in February & July (Round 2 & 6b). ▪ Water levels were high in February to April & July (Round 2, 3, 4 & 6b) and low in August to October (Round 8 - 10). The remaining months were observed as normal water levels.	▪ O&G: <5-5mg/L ▪ TSS: <5-180mg/L ▪ TP: <0.01-0.36mg/L ▪ TN: 0.3-1.8mg/L ▪ DO: 1.94-9.23mg/L ▪ EC: 100.5-423µS/cm ▪ pH: 5.32-7.04 ▪ Temp: 24.9-11.2ºC ▪ NTU: 12.5-36.7

Note: * Ch. = Highway Chainage

Section 6: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 6							
SW20 (SW6-01 and SW6-02)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.77	1.06	2.5	6.6	2.5	2.50	-	
Suspended Solids	mg/l	14.41	21.25	2.5	82	6.5	13.40	-	
Total Phosphorus as P	mg/l	0.06	0.06	0.01	0.25	0.04	0.07	-	
Total Nitrogen as N	mg/l	0.80	0.53	0.3	2.4	0.7	0.96	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.52	1.50	3.18	8.72	4.93	6.67	4.67	
Conductivity	µs/cm	924.13	459.92	231	1619	966	1324.60	481.40	
pH		6.40	0.77	3.74	7.02	6.55	6.75	6.29	
Temperature	°C	19.99	4.23	13.7	25.1	21	24.02	-	
Turbidity	NTU	30.71	39.43	3.67	154	14.9	32.18	-	
SW21 (SW6-03 and SW6-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.67	0.65	2.5	5	2.5	2.50	-	
Suspended Solids	mg/l	14.68	14.30	2.5	50	8.5	25.00	-	
Total Phosphorus as P	mg/l	0.04	0.06	0.005	0.25	0.02	0.04	-	
Total Nitrogen as N	mg/l	0.46	0.18	0.13	0.9	0.4	0.60	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.90	1.63	3.41	10.3	7.72	9.32	7.18	
Conductivity	µs/cm	262.71	136.48	86.6	543	200.9	360.80	174.56	
pH		6.64	0.51	5.93	7.33	6.57	7.15	6.18	
Temperature	°C	19.66	4.28	12.7	25.6	20.3	23.54	-	
Turbidity	NTU	18.70	9.70	11	47.9	14.2	22.80	-	
SW25 (SW6-05 and SW6-06									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.67	0.65	2.5	5	2.5	2.50	-	
Suspended Solids	mg/l	25.03	44.36	2.5	180	11	19.80	-	
Total Phosphorus as P	mg/l	0.06	0.10	0.005	0.36	0.03	0.03	-	
Total Nitrogen as N	mg/l	0.94	0.34	0.3	1.8	0.81	1.12	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.78	1.90	1.94	9.23	4.74	6.40	3.27	
Conductivity	µs/cm	194.65	87.56	100.5	423	164.7	251.40	139.74	
pH		6.27	0.48	5.32	7.04	6.37	6.61	5.85	
Temperature	°C	20.01	4.21	11.2	24.9	20.6	23.96	-	
Turbidity	NTU	22.09	7.55	12.5	36.7	19	30.36	-	

Section 6: Groundwater Monitoring

RMS did not nominate any groundwater wells to be monitored for Section 6 which does not contain significant cuttings or areas of extensive fill for construction of the Pacific Highway Upgrade.

Appendix F

Section 7 - Devils Pulpit to Trustums Hill: Pre-Construction Monitoring Results

Section 7: Surface Water Monitoring Locations and associated Sensitive Receiving Environments

Surface Water Sample Locations / Waterway	*Sensitive aquatic receiving environments and groundwater dependent ecosystems (GDE's)*
SW01 - Unnamed at CH 114 000 m	▪ potential habitat for threatened fish species / GDE
SW02 - Tabbimoble floodway no. 1	▪ potential habitat for threatened fish species / GDE
SW03 - Oaky Creek	▪ potential habitat for threatened fish species / GDE
SW04 - South of the intersection with the existing Pacific Highway and Norton's Road	▪ potential habitat for threatened fish species

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 7: Surface Water Monitoring – Overview of Results

Physical properties

Temperature generally exhibited a gradual increase generally from the low-teens (13-15°C) in winter up to the mid-20s (22-26°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. pH levels fell within the range of 3.7 to 7.2.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 0.5 mg/L. Total Nitrogen values were found to be in the range of 0.13 to 2.4 mg/L.

Heavy metals

Heavy metals were generally below detection limits.

Summary of Visual Observations and Sampling Results

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW01/GDE01 (Golder) Unnamed Ch. 113,950	▪ No record of visual observations provided.	▪ O&G: <5mg/L ▪ SS: <5-42mg/L ▪ TP: <0.01-0.09mg/L ▪ TN: 0.5-1.8mg/L ▪ DO: 5.9-10mg/L ▪ EC: 33-371µS/cm ▪ pH: 5-6.9 ▪ Temp: 13.3-23.6ºC ▪ NTU: 13-91
SW02/GDE02 (Golder) Tabbimoble Floodway No.1 Ch. 115,250	▪ As above.	▪ O&G: <5-5mg/L ▪ SS: <5-36mg/L ▪ TP: <0.01-0.13mg/L ▪ TN: 0.6-2mg/L ▪ DO: 1.3-8.1mg/L ▪ EC: 70-113µS/cm ▪ pH: 3.7-7.2 ▪ Temp: 12.8-26ºC ▪ NTU:10-88
SW03/GDE03 (Golder) Oaky Creek Ch. 122,400	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-22mg/L ▪ TP: <0.01-0.11mg/L ▪ TN: 0.3-0.8mg/L ▪ DO: 0.4-7.6mg/L ▪ EC: 133-187µS/cm ▪ pH: 4.0-6.7 ▪ Temp: 14.8-26ºC ▪ NTU: 3.1-47
SW04 (Golder) Unnamed Ch. 124,400	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-39mg/L ▪ TP: <0.01-0.08mg/L ▪ TN: 0.6-1.3mg/L ▪ DO: 0.5-7.8mg/L ▪ EC: 110-259µS/cm ▪ pH: 4.0-7.1 ▪ Temp: 13.7-22.2ºC ▪ NTU: 1.5-16.0

Note: * Ch. = Highway Chainage

Section 7: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 7							
SW01 (SW7-01 and SW7-02)									
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.75	0.79	5.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	16.20	15.40	42.00	2.5	10.0	31.8	-	
Total Phosphorus as P	mg/l	0.04	0.03	0.09	0.0	0.0	0.064	-	
Total Nitrogen as N	mg/l	2.66	2.63	8.60	0.5	1.7	4.4	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.68	1.09	10.00	5.9	7.8	8.1	6.988	
Conductivity	µs/cm	171.90	116.88	368.00	9.0	191.0	247.8	72.8	
pH		5.94	0.53	6.90	5.0	5.8	6.4	5.696	
Temperature	°C	20.23	3.21	23.60	13.3	21.7	22.52	-	
Turbidity	NTU	47.99	37.42	118.00	0.9	52.1	71.3	-	
SW02 (SW703 and SW7-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.69	0.69	5.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	15.31	9.01	36.00	2.5	16.0	18.6	-	
Total Phosphorus as P	mg/l	0.05	0.03	0.13	0.0	0.0	0.066	-	
Total Nitrogen as N	mg/l	0.92	0.35	2.00	0.6	0.9	1	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.91	2.42	8.10	1.3	6.8	7.8	3.2	
Conductivity	µs/cm	101.85	31.33	196.00	70.0	95.0	109	41	
pH		5.47	0.89	7.20	3.7	5.6	5.9	4.94	
Temperature	°C	19.08	4.06	25.90	12.8	18.9	22.4	-	
Turbidity	NTU	46.28	22.14	97.10	18.9	40.1	54.3	-	
SW03 (SW7-05 and SW7-06)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	5.12	5.73	22.00	2.5	2.5	5	-	
Total Phosphorus as P	mg/l	0.03	0.03	0.11	0.0	0.0	0.046	-	
Total Nitrogen as N	mg/l	0.63	0.26	1.20	0.4	0.5	0.76	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.96	2.52	7.60	0.4	5.8	7.2	2.24	
Conductivity	µs/cm	206.91	143.20	464.00	33.0	150.0	377	104	
pH		5.72	0.83	6.70	4.0	5.9	6.44	5.34	
Temperature	°C	19.38	4.00	26.00	14.2	19.1	23.4	-	
Turbidity	NTU	17.59	14.18	46.30	6.2	10.0	28.82	-	
SW04 (SW7-07 and SW7-08)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.86	0.94	5.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	13.00	14.69	39.00	2.5	2.5	24	-	
Total Phosphorus as P	mg/l	0.03	0.03	0.08	0.0	0.0	0.038	-	
Total Nitrogen as N	mg/l	0.79	0.25	1.30	0.6	0.7	0.88	-	

	Units	SECTION 7							
Field Physico-chemical data									
Dissolved Oxygen	mg/l	3.39	3.12	7.80	0.5	2.3	6.63	0.9	
Conductivity	µs/cm	110.67	52.97	190.00	52.0	109.0	140	64	
pH		4.90	1.11	7.10	4.0	4.6	4.8	4.3	
Temperature	$^{\circ}$C	17.98	3.60	22.20	13.7	17.8	21.16	-	
Turbidity	NTU	9.87	6.02	18.20	1.8	10.0	13.24	-	

Section 7: Groundwater Monitoring – Water Quality Overview

Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. Prior to measurement, approximately three times the borehole volume of groundwater was purged from each bore. The results for each quarter are shown in the table below.

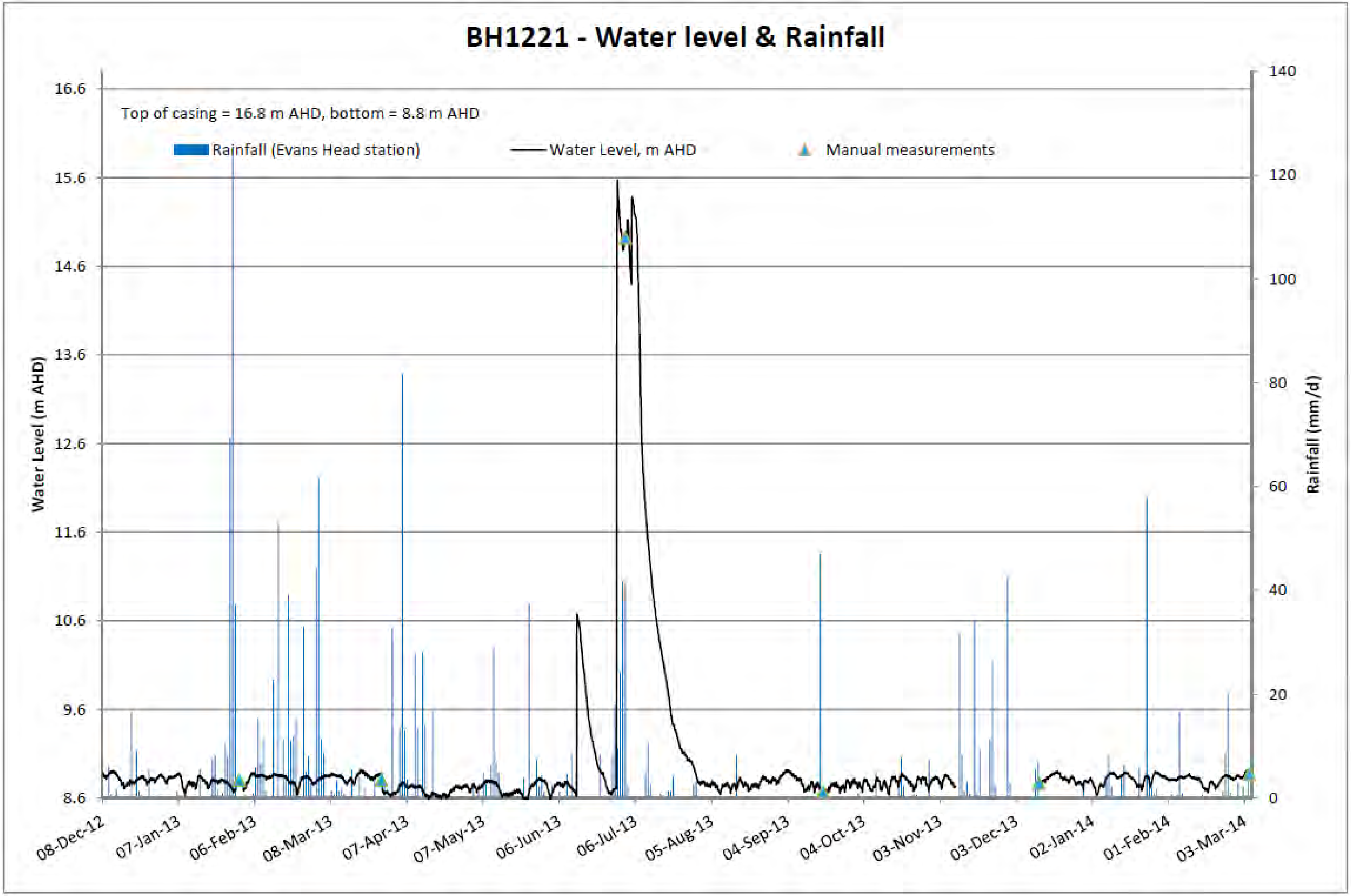
pH Statistics from Boreholes in Areas of Fill

Borehole Identifier	*Mean (Total)*	*Standard Deviation*	*Min*	*Max*	*Percentile*	
					P80	*P20*
BH1223	5.43	0.42	4.80	5.70	5.60	5.64
BH1224	4.88	0.54	4.30	5.60	4.80	5.12

Section 7: Groundwater Monitoring – Levels

Summary of Groundwater Level Monitoring – Section 7 DP2B Upgrade

Borehole Identifier	*Typical SWL (m below ground level)*		
	Average	*Median*	*Standard Deviation*
BH1221	-	-	-
BH1222	-	-	-
BH1223	9.18	9.20	0.107
BH1224	11.01	11.19	3.37
BH1225	6.75	7.01	1.07
BH1226	9.94	10.4	1.15
BH1227	6.7	6.74	0.64


BH1221 - Water level & Rainfall
Top of casing = 16.8 m AHD, bottom = 8.8 m AHD
Rainfall (Evans Head station)
Water Level, m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
16.6
15.6
14.6
13.6
12.6
11.6
10.6
9.6
8.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
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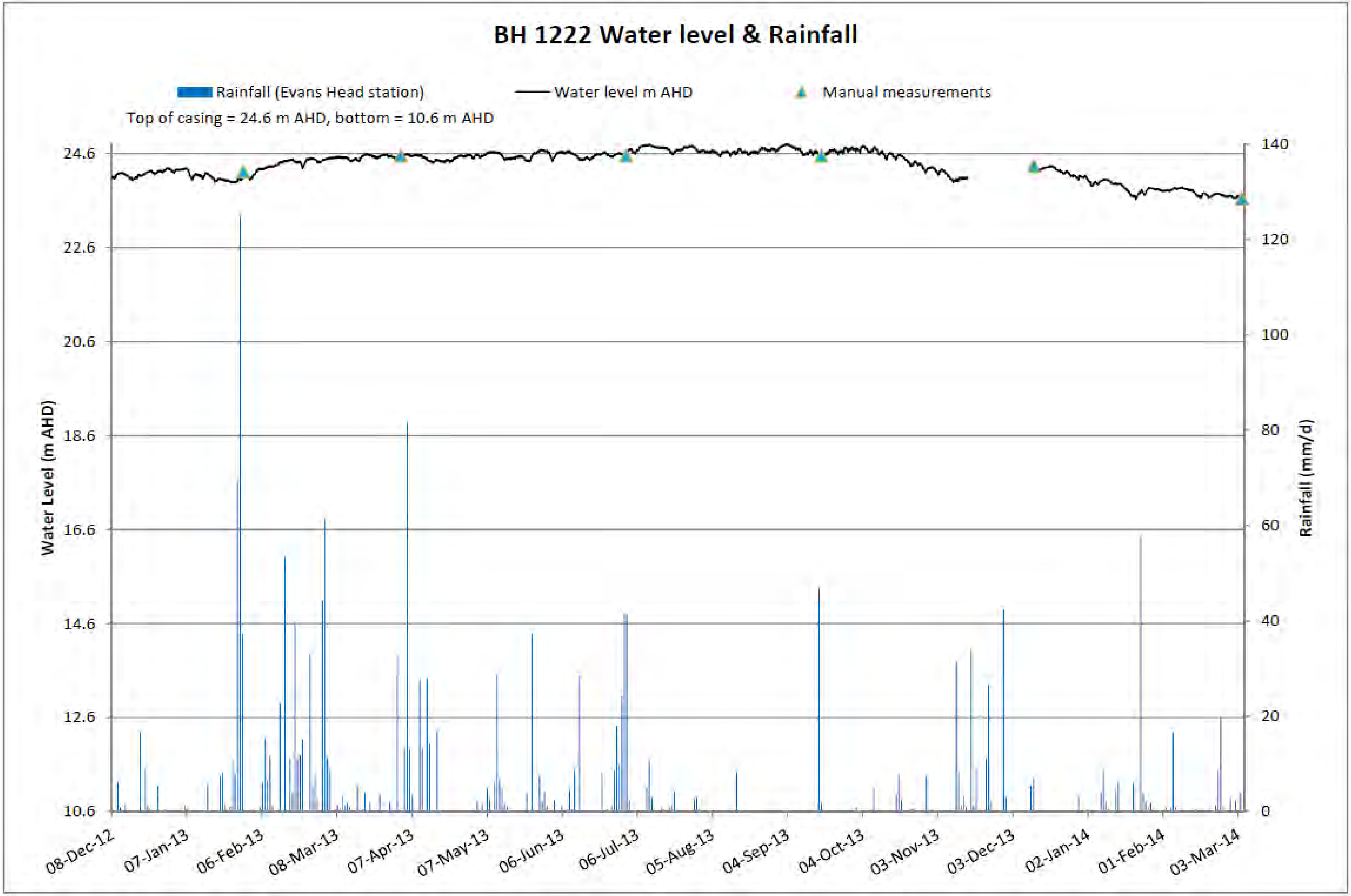
02-Jan-14
01-Feb-14
03-Mar-14


BH 1222 Water level & Rainfall
Rainfall (Evans Head station)
Water level m AHD
Manual measurements
Top of casing = 24.6 m AHD, bottom = 10.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
24.6
22.6
20.6
18.6
16.6
14.6
12.6
10.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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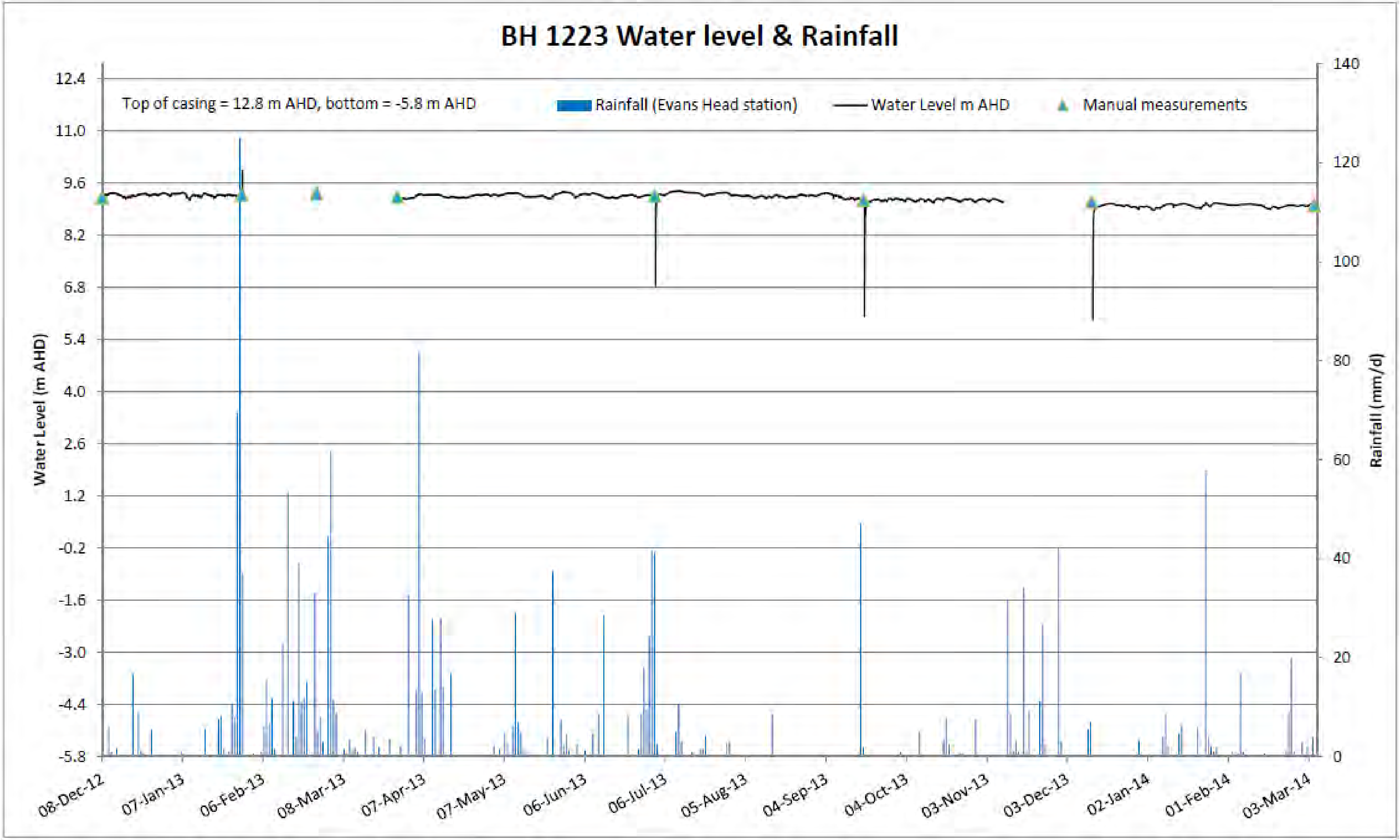
01-Feb-14
03-Mar-14



BH 1223 Water level & Rainfall
Top of casing = 12.8 m AHD, bottom = -5.8 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.4
11.0
9.6
8.2
6.8
5.4
4.0
2.6
1.2
-0.2
-1.6
-3.0
-4.4
-5.8
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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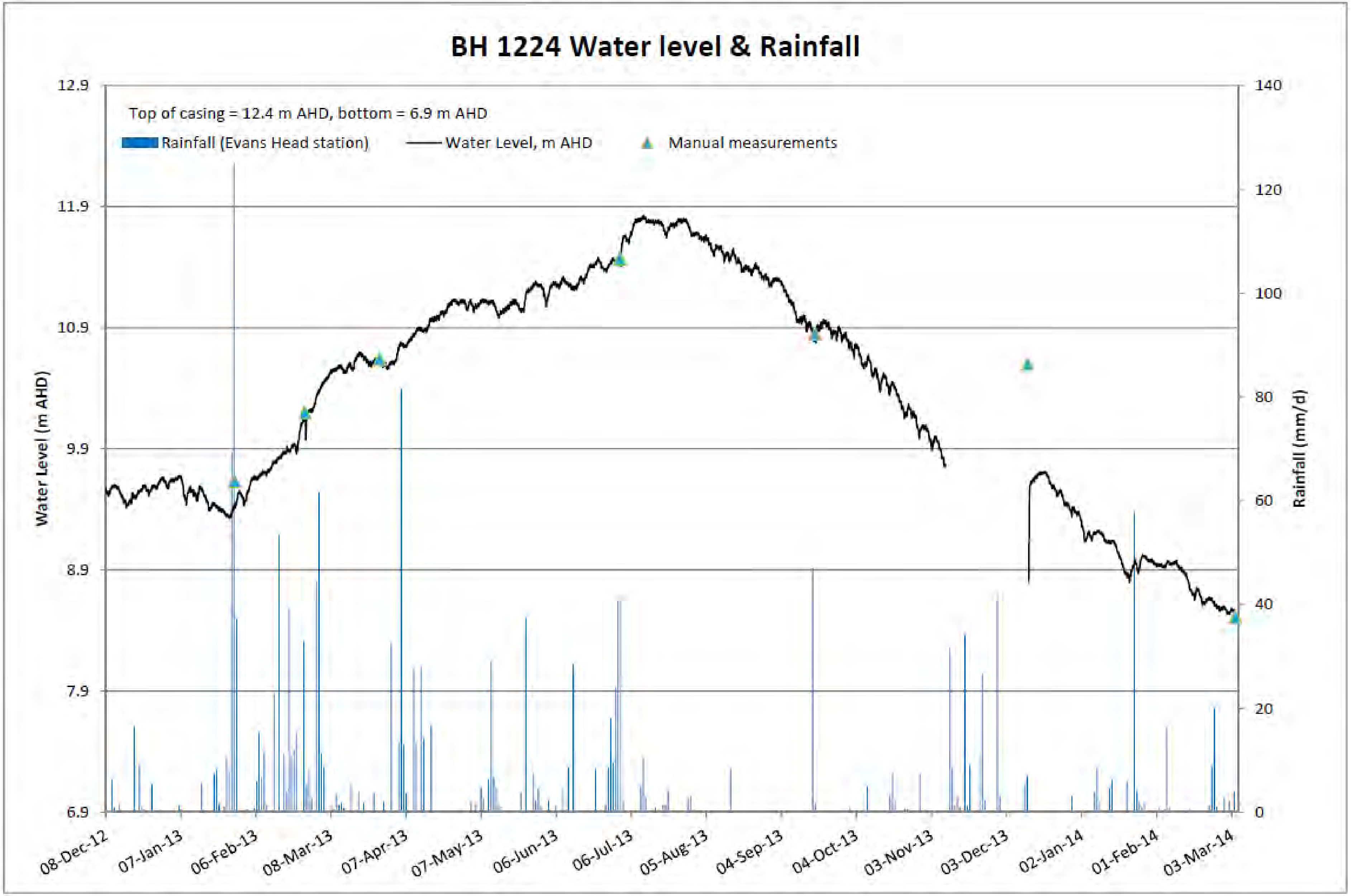
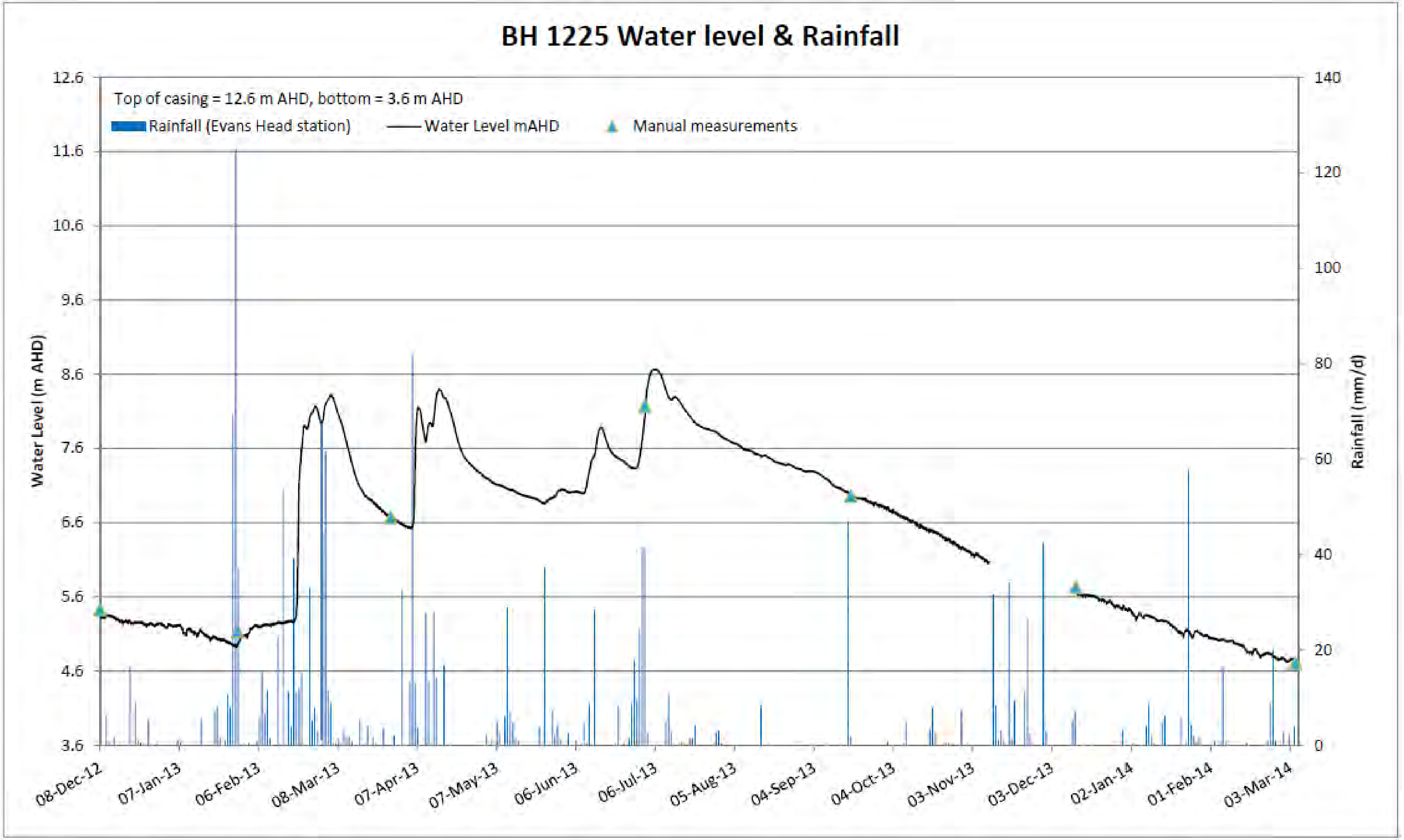
02-Jan-14
01-Feb-14
03-Mar-14


BH 1224 Water level & Rainfall
Top of casing = 12.4 m AHD, bottom = 6.9 m AHD
Rainfall (Evans Head station)
Water Level, m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.9
11.9
10.9
9.9
8.9
7.9
6.9
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1225 Water level & Rainfall
Top of casing = 12.6 m AHD, bottom = 3.6 m AHD
Rainfall (Evans Head station)
Water Level mAHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.6
11.6
10.6
9.6
8.6
7.6
6.6
5.6
4.6
3.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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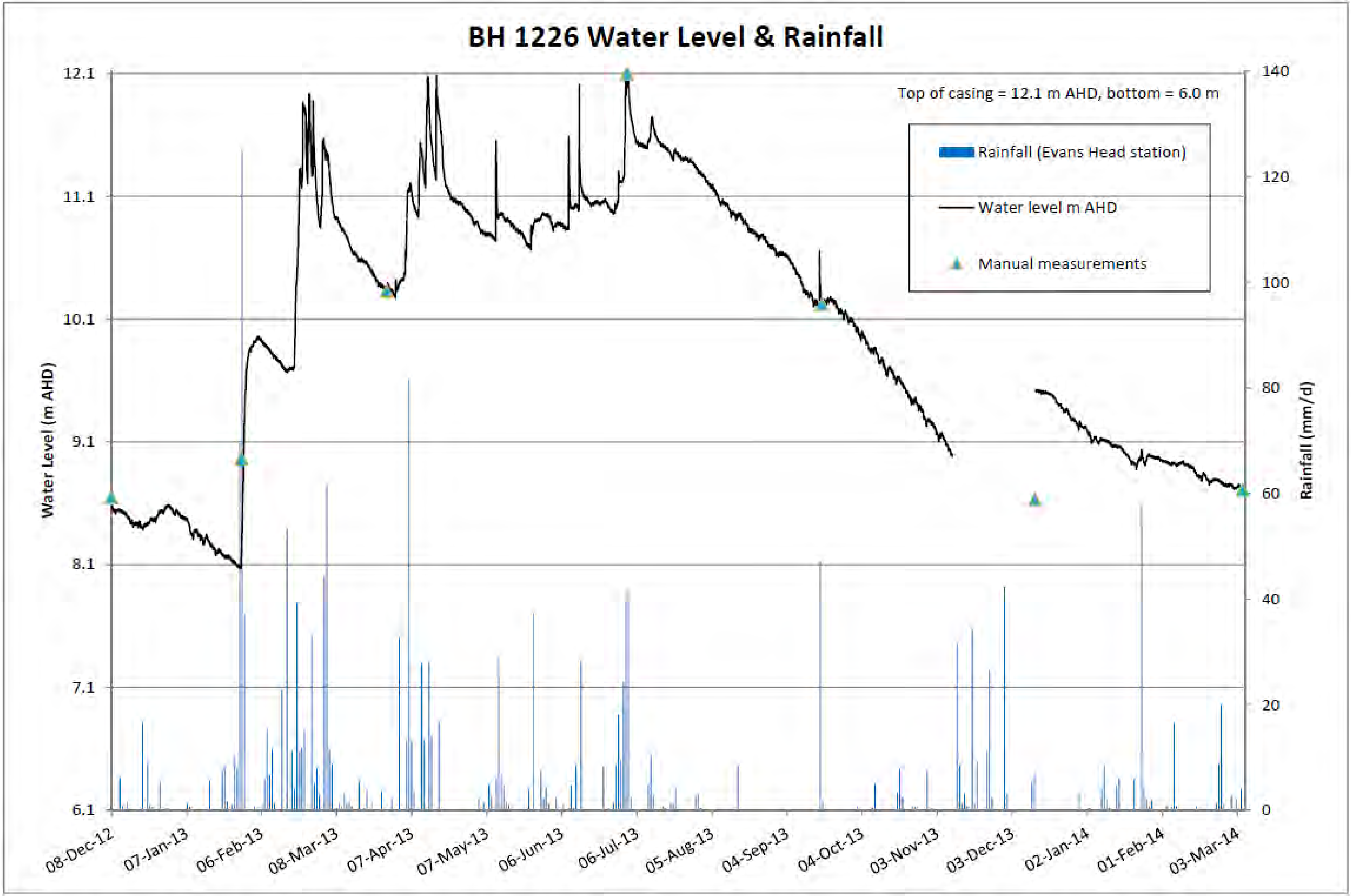
01-Feb-14
03-Mar-14


BH 1226 Water Level & Rainfall
Top of casing = 12.1 m AHD, bottom = 6.0 m
Rainfall (Evans Head station)
Water level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.1
11.1
10.1
9.1
8.1
7.1
6.1
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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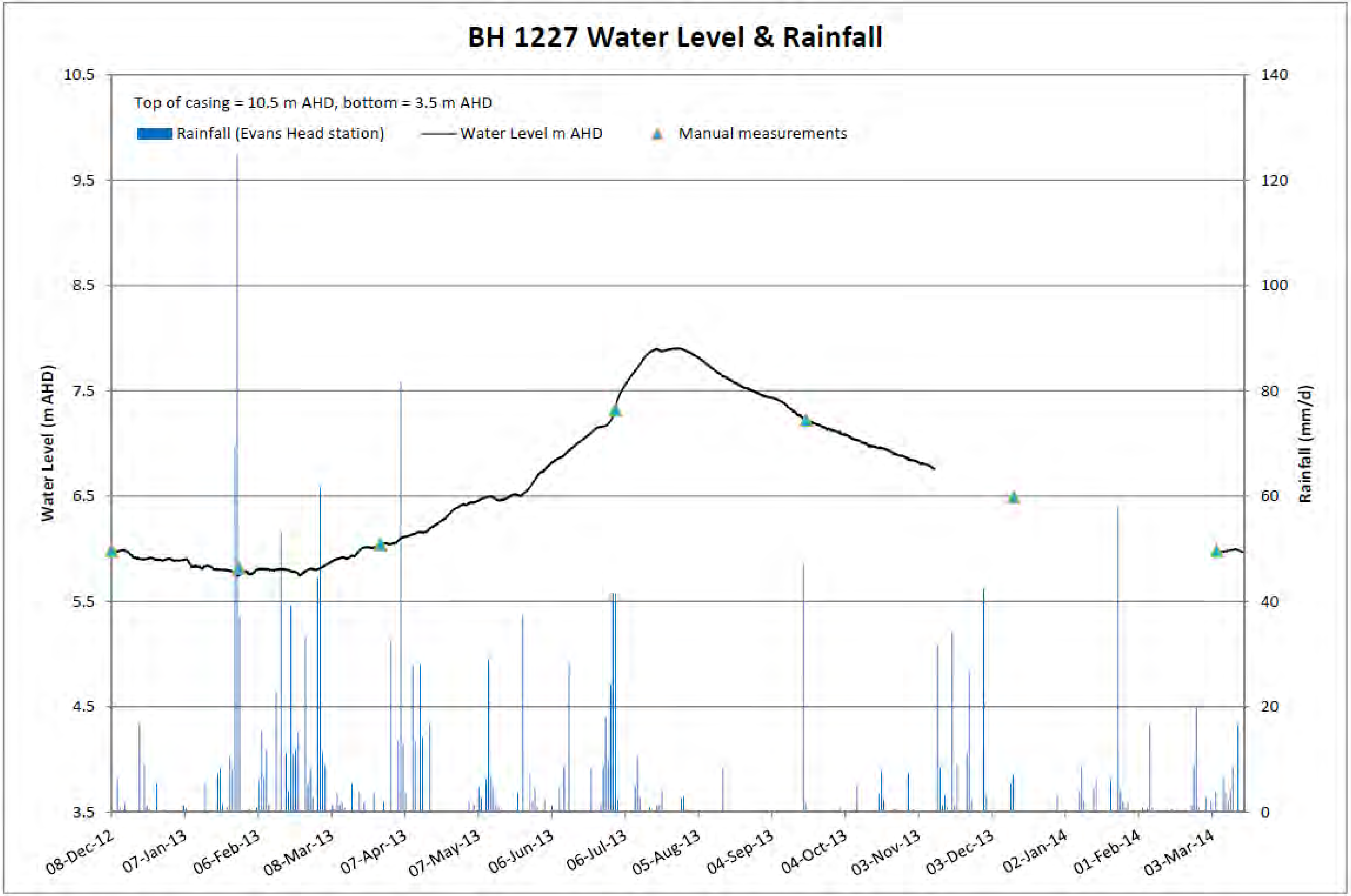
01-Feb-14
03-Mar-14



BH 1227 Water Level & Rainfall
Top of casing = 10.5 m AHD, bottom = 3.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

Appendix G

Section 8 - Trustums Hill to Broadwater National Park: Pre-Construction Monitoring Results

Section 8: Surface Water Monitoring Locations and associated Sensitive Receiving Environments

Surface Water Sample Locations / Waterway	*Sensitive aquatic receiving environments and groundwater dependent ecosystems (GDE's)*
SW05 - Tuckombil Canal (becomes Evans River)	▪ potential habitat for threatened fish species / Rous Water catchment
SW06 - Unnamed watercourse at CH 134 700 m	▪ potential habitat for threatened fish species / Rous Water catchment
SW07 - Unnamed tributary of MacDonald's Creek, CH 136 450 m	▪ potential habitat for threatened fish species / Rous Water catchment
SW08 - MacDonald's Creek	▪ potential habitat for threatened fish species / Rous Water catchment / GDE

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 8: Surface Water Monitoring – Overview of Results

Physical properties

Temperature generally exhibited a gradual increase generally from the high-teens (15-19°C) in winter up to the high-20s (26-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical properties

pH values were generally experienced a fair degree of variation for each water body. pH levels fell within the range of 3.5 to 9.3.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 3.31 mg/L. Total Nitrogen values were found to be in the range of <0.1 to 6.0 mg/L.

Heavy metals

Heavy metals were generally below detection limits.

Summary of Visual Observations and Sampling Results

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
GDE04 Swamp Area Ch. 130,350	▪ No record of visual observations provided.	▪ O&G: <5-5mg/L ▪ SS: 19-240mg/L ▪ TP: 0.14-3.31mg/L ▪ TN: 2.1-6.0mg/L ▪ DO: 3.5-11.3mg/L ▪ EC: 135-2620µS/cm ▪ pH: 3.5-6.1 ▪ Temp: 19.4-31.4ºC ▪ NTU: 7.5-58
GDE05 Swamp Area Ch. 133,300	▪ As above.	▪ O&G: <0.5mg/L ▪ SS: <0.5-25mg/L ▪ TP: 0.04-0.14mg/L ▪ TN: 0.8-1.7mg/L ▪ DO: 2.1-10mg/L ▪ EC: 104-292µS/cm ▪ pH: 5.1-8.3 ▪ Temp: 17.4-30ºC ▪ NTU: 3.3-12
SW05 Tuckombil Canal (becomes Evans River) Ch. 130,000	▪ As above.	▪ O&G: <5mg/L ▪ SS: 14-149mg/L ▪ TP: <0.01-0.21mg/L ▪ TN: <0.1-1.6mg/L ▪ DO: 2-10.8mg/L ▪ EC: 41-38,600µS/cm ▪ pH: 5.5-7.5 ▪ Temp: 18.1-27.1ºC ▪ NTU: 5.2-104
SW06 Unnamed watercourse Ch. 134,800	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-168mg/L ▪ TP: <0.01-0.61mg/L ▪ TN: 5.1-0.5mg/L ▪ DO: 3.4-10mg/L ▪ EC: 116-578µS/cm ▪ pH: 4.0-9.3 ▪ Temp: 16.6-29ºC ▪ NTU: 1.0-54.0
SW07 Unnamed tributary of Macdonald's Creek Ch.135,350	▪ As above.	▪ O&G: <5-6mg/L ▪ SS: <5-56mg/L ▪ TP: <0.01-0.21mg/L ▪ TN: 0.2-3.4mg/L ▪ DO: 1.9-8.9mg/L ▪ EC: 122-600µS/cm ▪ pH: 3.8-8.9 ▪ Temp: 15.4-26.7ºC ▪ NTU: 1.9-79
SW08/GDE06 Macdonald's Creek	▪ As above.	▪ O&G: 0.23-2.97mg/L ▪ SS: <5-13mg/L

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
Ch. 136,630		▪ TP: <0.01-1.15mg/L ▪ TN: 0.6-0.8mg/L ▪ DO: 1.7-8.1mg/L ▪ EC: 110-654µS/cm ▪ pH: 3.6-6.3 ▪ Temp: 14.9-26ºC ▪ NTU: 0.8-8.6

Note: * Ch. = Highway Chainage

Section 8: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 8							
SW05 (SW8-01 and SW8-02)									
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	40.58	35.92	149.00	14.0	31.0	39.6	-	
Total Phosphorus as P	mg/l	0.24	0.29	1.07	0.0	0.2	0.21	-	
Total Nitrogen as N	mg/l	0.78	0.50	1.60	0.1	0.8	1.18	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.66	2.12	10.80	2.0	7.9	8.7	6.92	
Conductivity	µs/cm	15337.08	13268.43	38600.00	41.0	13100.0	29848	3321.2	
pH		6.76	0.59	7.50	5.5	6.8	7.36		
Temperature	°C	23.80	2.99	27.10	18.1	24.7	26	-	
Turbidity	NTU	40.42	64.20	232.00	10.4	18.9	35	-	
GDE04									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	3.13	1.25	5.00	2.5	2.5	3.5	-	
Suspended Solids	mg/l	87.50	102.94	240.00	19.0	45.5	130.8	-	
Total Phosphorus as P	mg/l	2.14	1.45	3.31	0.1	2.5	3.184	-	
Total Nitrogen as N	mg/l	4.38	1.64	6.00	2.1	4.7	5.34	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.74	4.06	11.30	3.5	5.4	8.94	4.266	
Conductivity	µs/cm	846.33	1145.21	2153.00	17.0	369.0	1439.4	157.8	
pH		4.64	1.33	6.10	3.5	4.3	5.38	3.826	
Temperature	°C	25.40	8.49	31.40	19.4	25.4	29	-	
Turbidity	NTU	108.60	137.74	206.00	11.2	108.6	167.04	-	
GDE05									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	9.18	6.57	25.00	2.5	8.0	10	-	
Total Phosphorus as P	mg/l	0.08	0.03	0.14	0.0	0.1	0.09	-	
Total Nitrogen as N	mg/l	1.13	0.31	1.70	0.8	1.0	1.4	-	
Dissolved Oxygen	mg/l	7.29	2.49	9.70	2.1	8.1	8.76	6.592	

	Units	SECTION 8							
Conductivity	µs/cm	598.80	379.61	1408.00	145.0	642.0	786.8	190.2	
pH		6.75	1.07	8.30	5.1	6.8	7.62	5.92	
Temperature	°C	24.06	4.04	30.00	17.4	25.0	26.68	-	
Turbidity	NTU	8.77	1.77	11.70	5.7	9.2	9.98	-	
SW06 (SW8-03 and SW8-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	28.86	48.67	168.00	2.5	14.0	37	-	
Total Phosphorus as P	mg/l	0.14	0.18	0.61	0.0	0.1	0.16	-	
Total Nitrogen as N	mg/l	1.39	1.31	5.10	0.5	1.0	1.7	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	8.10	1.98	10.00	3.4	8.7	9.36	7.1	
Conductivity	µs/cm	266.00	172.36	537.00	102.0	183.0	473.2	133.2	
pH		5.18	1.77	9.30	4.0	4.3	6.22	4.132	
Temperature	°C	23.80	4.37	29.00	16.6	25.1	27.82	-	
Turbidity	NTU	21.13	38.41	122.00	1.3	9.1	16.24	-	
SW07 (SW8-05 and SW8-06)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.79	1.01	6.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	16.92	18.69	56.00	2.5	6.8	34	-	
Total Phosphorus as P	mg/l	0.05	0.07	0.21	0.0	0.0	0.088	-	
Total Nitrogen as N	mg/l	1.02	0.96	3.40	0.2	0.5	1.74	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.05	1.96	8.90	3.1	6.1	8.2	4.11	
Conductivity	µs/cm	217.92	149.25	606.00	92.0	154.0	313.2	113	
pH		5.00	1.38	8.90	3.8	4.5	5.26	4.3	
Temperature	°C	22.50	3.81	26.70	15.4	22.5	26.32	-	
Turbidity	NTU	25.15	41.38	138.00	2.4	11.4	24.9	-	
SW08 (SW8-07 and SW8-08)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	5.45	3.83	13.00	2.5	4.3	7	-	
Total Phosphorus as P	mg/l	0.16	0.37	1.15	0.0	0.0	0.048	-	
Total Nitrogen as N	mg/l	0.67	0.07	0.80	0.6	0.7	0.7	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.58	2.49	8.10	1.7	4.4	6.86	2.136	
Conductivity	µs/cm	329.90	150.63	527.00	164.0	284.0	515.2	183	
pH		4.43	0.82	6.25	3.4	4.4	4.78		
Temperature	°C	20.57	3.31	25.60	14.9	21.7	22.76	-	
Turbidity	NTU	4.24	4.14	14.20	0.7	3.1	6.492	-	

Section 8: Groundwater Monitoring – Water Quality

Water Quality for Bores Next to the Rous Water Extraction Borefield

The following three table show the water quality monitoring statistics for bores BH1242, BH1243 and BH1244.

		BH1242						
Parameter	Units	Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
pH Value (field)	pH Unit	5.23	0.31	4.80	5.50	5.30	5.44	5.04
pH Value (lab)	pH Unit	6.89	0.49	6.54	7.60	6.72	7.13	6.58
Temperature (field)	ºC	19.20	0.67	18.60	20.00	19.10	19.70	18.66
Electrical Conductivity @ 25°C (lab)	µS/cm	286.25	7.85	276.00	295.00	287.00	290.80	282.00
Electrical Conductivity (field)	µS/cm	268.50	44.32	223.00	329.00	261.00	291.20	242.80
Total Dissolved Solids @180°C	mg/L	183.00	17.80	165.00	202.00	182.50	197.20	168.60
Suspended Solids (SS)	mg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Turbidity (field)	NTU	3.10	0.56	2.60	3.70	3.00	3.42	2.76
Turbidity (lab)	NTU	6.88	1.51	4.70	7.90	7.45	7.90	6.08
Redox Potential (field)		50.90	61.80	10.60	143.00	25.00	73.40	18.04
Redox Potential (lab)	mV	-7.30	61.77	-69.20	66.00	-13.00	38.40	-55.28
pH Redox	pH Unit	6.15	0.07	6.10	6.20	6.15	6.18	6.12
Hydroxide Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Carbonate Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Bicarbonate Alkalinity as CaCO3	mg/L	38.50	3.11	36.00	43.00	37.50	40.00	36.60
Total Alkalinity as CaCO3	mg/L	38.50	3.11	36.00	43.00	37.50	40.00	36.60
Sulfate as SO4 - Turbidimetric	mg/L	12.25	1.71	10.00	14.00	12.50	13.40	11.20
Chloride	mg/L	55.50	2.89	52.00	59.00	55.50	57.20	53.80
Calcium	mg/L	2.50	0.58	2.00	3.00	2.50	3.00	2.00
Magnesium	mg/L	4.00	0.00	4.00	4.00	4.00	4.00	4.00
Sodium	mg/L	46.00	1.41	45.00	48.00	45.50	46.80	45.00
Potassium	mg/L	2.25	0.50	2.00	3.00	2.00	2.40	2.00
Aluminium	mg/L	0.04	0.01	0.03	0.04	0.04	0.04	0.03
Antimony	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	mg/L	0.05	0.00	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	mg/L	0.06	0.03	0.03	0.09	0.06	0.08	0.04
Molybdenum	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Silver	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	mg/L	0.01	0.01	0.00	0.01	0.01	0.01	0.00
Boron	mg/L	0.03	0.00	0.03	0.03	0.03	0.03	0.03
Iron	mg/L	6.34	0.56	5.51	6.72	6.56	6.67	6.09
Mercury	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fluoride	mg/L	0.18	0.22	0.05	0.50	0.08	0.26	0.05
Ammonia as N	mg/L	0.07	0.05	0.04	0.14	0.06	0.09	0.05
Nitrite + Nitrate as N	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Total Kjeldahl Nitrogen as N	mg/L	0.28	0.05	0.20	0.30	0.30	0.30	0.26

		BH1242						
Parameter	Units	Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
Total Nitrogen as N	mg/L	0.28	0.05	0.20	0.30	0.30	0.30	0.26
Total Phosphorus as P	mg/L	0.07	0.05	0.04	0.14	0.06	0.09	0.05
Total Anions	meq/L	2.59	0.10	2.48	2.73	2.58	2.65	2.53
Total Cations	meq/L	2.51	0.07	2.46	2.62	2.49	2.54	2.47
Oil & Grease	mg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Dissolved Oxygen (lab)	mg/L	4.30	2.07	1.90	6.80	4.25	5.66	2.92
Dissolved Oxygen (field)	mg/L	3.23	1.22	1.40	4.00	3.75	3.88	2.78
Benzene	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Toluene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Ethylbenzene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
meta- & para-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
ortho-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Total Xylenes	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Sum of BTEX	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Naphthalene	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C6 - C9 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C10 - C14 Fraction	µg/L	31.88	58.75	2.50	120.00	2.50	49.50	2.50
C15 - C28 Fraction	µg/L	392.50	430.92	120.00	1030.00	210.00	580.00	132.00
C29 - C36 Fraction	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C10 - C36 Fraction (sum)	µg/L	422.50	424.61	120.00	1030.00	270.00	652.00	132.00
C6 - C10 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C6 - C10 Fraction minus BTEX (F1)	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
>C10 - C16 Fraction	µg/L	370.00	392.68	110.00	940.00	215.00	568.00	110.00
>C16 - C34 Fraction	µg/L	67.75	82.75	0.50	170.00	50.25	128.00	0.50
>C34 - C40 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C10 - C40 Fraction (sum)	µg/L	437.50	471.55	110.00	1110.00	265.00	696.00	110.00
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	110.00	0.00	110.00	110.00	110.00	110.00	110.00
1.2-Dichloroethane-D4	%	92.20	5.15	86.30	98.50	92.00	95.56	88.76
Toluene-D8	%	94.28	5.65	87.30	100.00	94.90	98.50	90.30
4-Bromofluorobenzene	%	90.03	4.79	83.50	94.50	91.05	93.30	87.16
Faecal Coliforms	CFU/100 mL	5.88	10.75	0.50	22.00	0.50	9.10	0.50

		BH1243						
Parameter	Units	Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
pH Value (lab)	pH Unit	6.82	0.45	6.53	7.49	6.63	7.00	6.56
pH Value (field)	pH Unit	5.33	0.05	5.30	5.40	5.30	5.34	5.30
Temperature (field)	ºC	19.00	0.54	18.40	19.70	18.95	19.28	18.70
Electrical Conductivity @ 25°C (lab)	µS/cm	402.25	24.19	367.00	421.00	410.50	416.80	391.00
Electrical Conductivity (field)	µS/cm	379.00	53.99	324.00	447.00	372.50	415.80	339.60
Total Dissolved Solids @180°C	mg/L	225.75	17.23	201.00	238.00	232.00	237.40	216.60
Suspended Solids (SS)	mg/L	16.00	8.72	11.00	29.00	12.00	19.40	11.00
Turbidity (field)	NTU	12.90	2.91	10.70	16.20	11.80	14.44	11.14
Turbidity (lab)	NTU	19.30	13.50	6.60	35.00	17.80	29.60	8.40
Redox Potential (field)	mV	72.10	52.02	26.40	141.00	60.50	106.20	33.36
Redox Potential (lab)	mV	12.58	53.60	-46.90	77.30	9.95	49.46	-25.36
pH Redox	pH Unit	6.00	0.14	5.90	6.10	6.00	6.06	5.94
Hydroxide Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Carbonate Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50

		BH1243						
Parameter	Units	Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
Bicarbonate Alkalinity as CaCO3	mg/L	27.25	4.50	21.00	31.00	28.50	30.40	24.60
Total Alkalinity as CaCO3	mg/L	27.25	4.50	21.00	31.00	28.50	30.40	24.60
Sulfate as SO4 - Turbidimetric	mg/L	24.25	0.50	24.00	25.00	24.00	24.40	24.00
Chloride	mg/L	87.75	9.43	77.00	99.00	87.50	94.20	81.20
Calcium	mg/L	3.75	0.50	3.00	4.00	4.00	4.00	3.60
Magnesium	mg/L	4.50	0.58	4.00	5.00	4.50	5.00	4.00
Sodium	mg/L	65.50	6.03	60.00	74.00	64.00	68.60	61.80
Potassium	mg/L	3.00	0.00	3.00	3.00	3.00	3.00	3.00
Aluminium	mg/L	0.01	0.01	0.01	0.02	0.01	0.02	0.01
Antimony	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	mg/L	0.04	0.01	0.03	0.05	0.05	0.05	0.04
Cadmium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	mg/L	0.06	0.01	0.05	0.07	0.06	0.07	0.06
Molybdenum	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Silver	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	mg/L	0.01	0.00	0.00	0.01	0.00	0.01	0.00
Boron	mg/L	0.03	0.02	0.03	0.06	0.03	0.04	0.03
Iron	mg/L	8.56	0.62	7.72	9.20	8.66	8.92	8.24
Mercury	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fluoride	mg/L	0.14	0.18	0.05	0.40	0.05	0.19	0.05
Ammonia as N	mg/L	0.07	0.08	0.01	0.18	0.05	0.11	0.02
Nitrite + Nitrate as N	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Total Kjeldahl Nitrogen as N	mg/L	0.30	0.12	0.20	0.40	0.30	0.40	0.20
Total Nitrogen as N	mg/L	0.30	0.12	0.20	0.40	0.30	0.40	0.20
Total Phosphorus as P	mg/L	0.03	0.02	0.01	0.05	0.03	0.04	0.01
Total Anions	meq/L	3.53	0.22	3.31	3.83	3.48	3.63	3.41
Total Cations	meq/L	3.49	0.29	3.30	3.91	3.37	3.59	3.33
Ionic Balance	%	1.13	0.70	0.24	1.82	1.23	1.64	0.66
Oil & Grease	mg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Benzene	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Toluene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Ethylbenzene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
meta- & para-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
ortho-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Total Xylenes	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Sum of BTEX	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Naphthalene	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Dissolved Oxygen (lab)	mg/L	4.95	1.53	3.20	6.80	4.90	5.96	3.92
Dissolved Oxygen (field)	mg/L	3.23	1.08	1.80	4.20	3.45	4.02	2.52
C6 - C9 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C10 - C14 Fraction	µg/L	14.38	23.75	2.50	50.00	2.50	21.50	2.50
C15 - C28 Fraction	µg/L	62.75	72.00	0.50	130.00	60.25	124.00	0.50
C29 - C36 Fraction	µg/L	14.38	23.75	2.50	50.00	2.50	21.50	2.50
C10 - C36 Fraction (sum)	µg/L	88.75	106.15	2.50	220.00	66.25	166.00	2.50
C6 - C10 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C6 - C10 Fraction minus BTEX (F1)	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
>C10 - C16 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50

		BH1243						
Parameter	Units	Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
>C16 - C34 Fraction	µg/L	35.38	69.75	0.50	140.00	0.50	56.30	0.50
>C34 - C40 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C10 - C40 Fraction (sum)	µg/L	35.38	69.75	0.50	140.00	0.50	56.30	0.50
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
1.2-Dichloroethane-D4	%	93.38	8.77	86.30	105.00	91.10	99.18	86.66
Toluene-D8	%	96.48	5.52	90.00	102.00	96.95	100.80	92.34
4-Bromofluorobenzene	%	91.28	9.93	79.00	103.00	91.55	97.30	85.36
Faecal Coliforms	CFU/100 mL	6.88	12.75	0.50	26.00	0.50	10.70	0.50

		BH1244						
Parameter	Units	Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
pH Value (lab)	pH Unit	6.78	0.45	6.50	7.30	6.54	7.00	6.52
pH Value (field)	pH Unit	5.33	0.06	5.30	5.40	5.30	5.36	5.30
Temperature (field)	ºC	19.33	0.70	18.60	20.00	19.40	19.76	18.92
Electrical Conductivity (field)	µS/cm	354.00	58.23	293.00	409.00	360.00	389.40	319.80
Electrical Conductivity @ 25°C (lab)	µS/cm	366.67	8.33	360.00	376.00	364.00	371.20	361.60
Total Dissolved Solids @180°C	mg/L	210.00	9.54	201.00	220.00	209.00	215.60	204.20
Suspended Solids (SS)	mg/L	3.67	2.02	2.50	6.00	2.50	4.60	2.50
Turbidity (field)	NTU	2.43	0.23	2.30	2.70	2.30	2.54	2.30
Turbidity (lab)	NTU	2.97	1.15	2.30	4.30	2.30	3.50	2.30
Redox Potential (field)	mV	72.33	43.10	31.00	117.00	69.00	97.80	46.20
Redox Potential (lab)	mV	40.73	32.16	20.30	77.80	24.10	56.32	21.82
pH Redox	pH Unit	6.00	#DIV/0!	6.00	6.00	6.00	6.00	6.00
Hydroxide Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Carbonate Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Bicarbonate Alkalinity as CaCO3	mg/L	26.33	2.08	24.00	28.00	27.00	27.60	25.20
Total Alkalinity as CaCO3	mg/L	26.33	2.08	24.00	28.00	27.00	27.60	25.20
Sulfate as SO4 - Turbidimetric	mg/L	30.67	1.15	30.00	32.00	30.00	31.20	30.00
Chloride	mg/L	72.67	3.06	70.00	76.00	72.00	74.40	70.80
Calcium	mg/L	1.67	0.58	1.00	2.00	2.00	2.00	1.40
Magnesium	mg/L	3.33	0.58	3.00	4.00	3.00	3.60	3.00
Sodium	mg/L	62.00	2.00	60.00	64.00	62.00	63.20	60.80
Potassium	mg/L	2.67	0.58	2.00	3.00	3.00	3.00	2.40
Aluminium	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Antimony	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	mg/L	0.04	0.01	0.04	0.05	0.05	0.05	0.04
Cadmium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	mg/L	0.02	0.01	0.01	0.03	0.02	0.03	0.02
Molybdenum	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Silver	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Parameter	Units	BH1244						
		Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile 80	Percentile 20
Zinc	mg/L	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Boron	mg/L	0.03	0.01	0.03	0.05	0.03	0.04	0.03
Iron	mg/L	7.21	0.28	7.00	7.53	7.09	7.35	7.04
Mercury	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fluoride	mg/L	0.05	0.00	0.05	0.05	0.05	0.05	0.05
Ammonia as N	mg/L	0.15	0.06	0.08	0.18	0.18	0.18	0.12
Nitrite + Nitrate as N	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Total Kjeldahl Nitrogen as N	mg/L	0.40	0.17	0.30	0.60	0.30	0.48	0.30
Total Nitrogen as N	mg/L	0.40	0.17	0.30	0.60	0.30	0.48	0.30
Total Phosphorus as P	mg/L	0.02	0.01	0.02	0.03	0.02	0.03	0.02
Total Anions	meq/L	3.22	0.08	3.14	3.29	3.22	3.26	3.17
Total Cations	meq/L	3.12	0.09	3.04	3.21	3.12	3.17	3.07
Ionic Balance	%	1.48	0.17	1.29	1.62	1.52	1.58	1.38
Oil & Grease	mg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Benzene	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Toluene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Ethylbenzene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
meta- & para-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
ortho-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Total Xylenes	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Sum of BTEX	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Naphthalene	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Dissolved Oxygen (lab)	mg/L	4.27	2.10	2.20	6.40	4.20	5.52	3.00
Dissolved Oxygen (field)	mg/L	3.30	0.75	2.50	4.00	3.40	3.76	2.86
C6 - C9 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C10 - C14 Fraction	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C15 - C28 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
C29 - C36 Fraction	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C10 - C36 Fraction (sum)	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C6 - C10 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C6 - C10 Fraction minus BTEX (F1)	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
>C10 - C16 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C16 - C34 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C34 - C40 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C10 - C40 Fraction (sum)	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
1.2-Dichloroethane-D4	%	95.80	8.41	87.20	104.00	96.20	100.88	90.80
Toluene-D8	%	100.70	8.33	91.10	106.00	105.00	105.60	96.66
4-Bromofluorobenzene	%	97.40	5.39	91.20	101.00	100.00	100.60	94.72
Faecal Coliforms	CFU/100 mL	0.50	0.00	0.50	0.50	0.50	0.50	0.50

pH Statistics

Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. Prior to measurement, approximately three times the borehole volume of groundwater was purged from each bore. The results for each quarter are shown in the table below.

pH Statistics from Boreholes in Areas of Fill

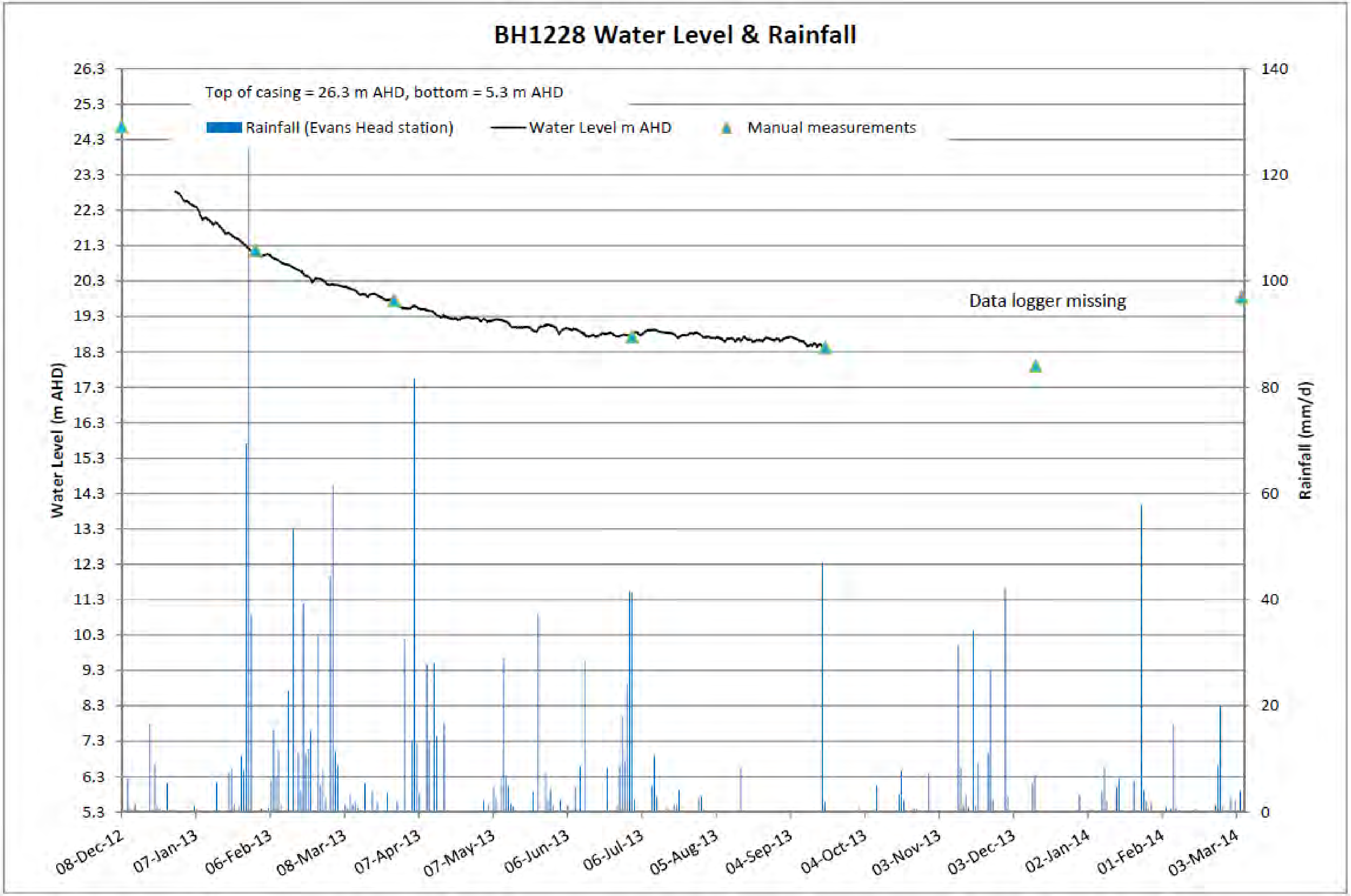
Borehole Identifier	*Mean (Total)*	*Standard Deviation*	*Min*	*Max*	*Percentile*	
					P80	*P20*
BH1230	5.28	0.35	4.90	5.70	5.25	5.52
BH1231	5.45	0.44	5.00	6.00	5.40	5.76
BH1232	4.25	0.65	3.80	5.20	4.00	4.54
BH1233	4.10	0.24	3.90	4.40	4.05	4.28
BH1234	4.98	0.68	4.10	5.60	5.10	5.48
BH1235	5.48	0.79	4.40	6.20	5.65	6.02
BH1236	6.63	0.24	6.30	6.80	6.70	6.80
BH1237	6.55	0.21	6.30	6.80	6.55	6.68
BH1238	6.05	0.69	5.10	6.60	6.25	6.54
BH1239	6.15	0.69	5.20	6.70	6.35	6.64
BH1240	5.53	0.75	4.40	6.00	5.85	5.94
BH1241	5.00	0.81	3.80	5.60	5.30	5.42
BH1242	5.30	0.18	5.10	5.50	5.30	5.44
BH1243	5.33	0.05	5.30	5.40	5.30	5.34
BH1244	5.33	0.06	5.30	5.40	5.30	5.36
BH1245	N/A	N/A	N/A	N/A	N/A	N/A
BH1246	5.43	0.31	5.00	5.70	5.50	5.64
BH1247	5.00	0.36	4.50	5.30	5.10	5.24
BH1248	5.45	0.66	4.50	5.90	5.70	5.90
BH1251	4.70	1.08	3.30	5.90	4.80	5.36
BH1252	4.98	1.09	3.50	5.90	5.25	5.78
BH1253	5.30	0.51	4.60	5.80	5.40	5.62

Section 8: Groundwater Monitoring – Levels

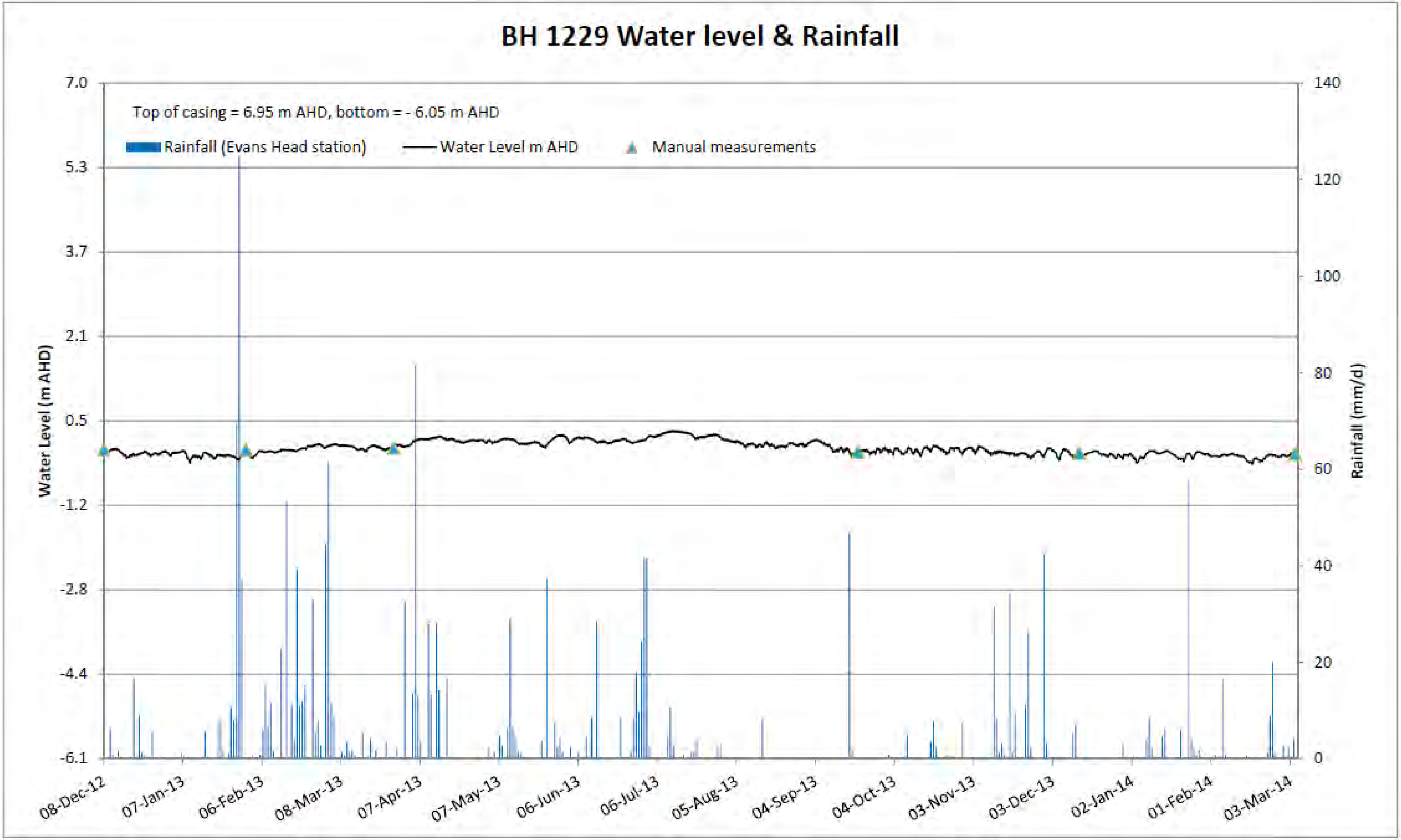
Summary of Groundwater Level Monitoring – Section 8 DP2B Upgrade

Borehole Identifier	*Typical SWL (m below ground level)*		
	Average	*Median*	*Standard Deviation*
BH1229	-0.1	-0.1	0.03
BH1230	1.7	1.61	0.63
BH1231	2.66	2.51	0.62
BH1232	0.64	0.88	0.42
BH1233	0.79	0.93	0.44
BH1234	0.68	0.62	0.61
BH1235	0.74	0.62	0.53

Borehole Identifier	Typical SWL (m below ground level)		
	Average	Median	Standard Deviation
BH1236	0.72	0.82	0.58
BH1237	0.66	0.8	0.45
BH1238	-	-	-
BH1239	0.22	0.17	0.25
BH1240	1.15	1.03	0.38
BH1241	1.59	1.61	0.27
BH1242	1.56	1.39	0.56
BH1243	1.41	1.28	0.51
BH1244	0.33	0.34	0.07
BH1245	1.4	1.47	0.46
BH1246	1.58	1.71	0.46
BH1247	0.22	0.17	0.25
BH1248	-	-	-
BH1249	-	-	-
BH1250	-	-	-
BH1251	1.63	1.72	0.28
BH1252	1.15	1.14	0.17
BH1253	1.23	1.22	0.16



BH1228 Water Level & Rainfall
Top of casing = 26.3 m AHD, bottom = 5.3 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Data logger missing
Water Level (m AHD)
Rainfall (mm/d)
26.3
25.3
24.3
23.3
22.3
21.3
20.3
19.3
18.3
17.3
16.3
15.3
14.3
13.3
12.3
11.3
10.3
9.3
8.3
7.3
6.3
5.3
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1229 Water level & Rainfall
Top of casing = 6.95 m AHD, bottom = - 6.05 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
7.0
5.3
3.7
2.1
0.5
-1.2
-2.8
-4.4
-6.1
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
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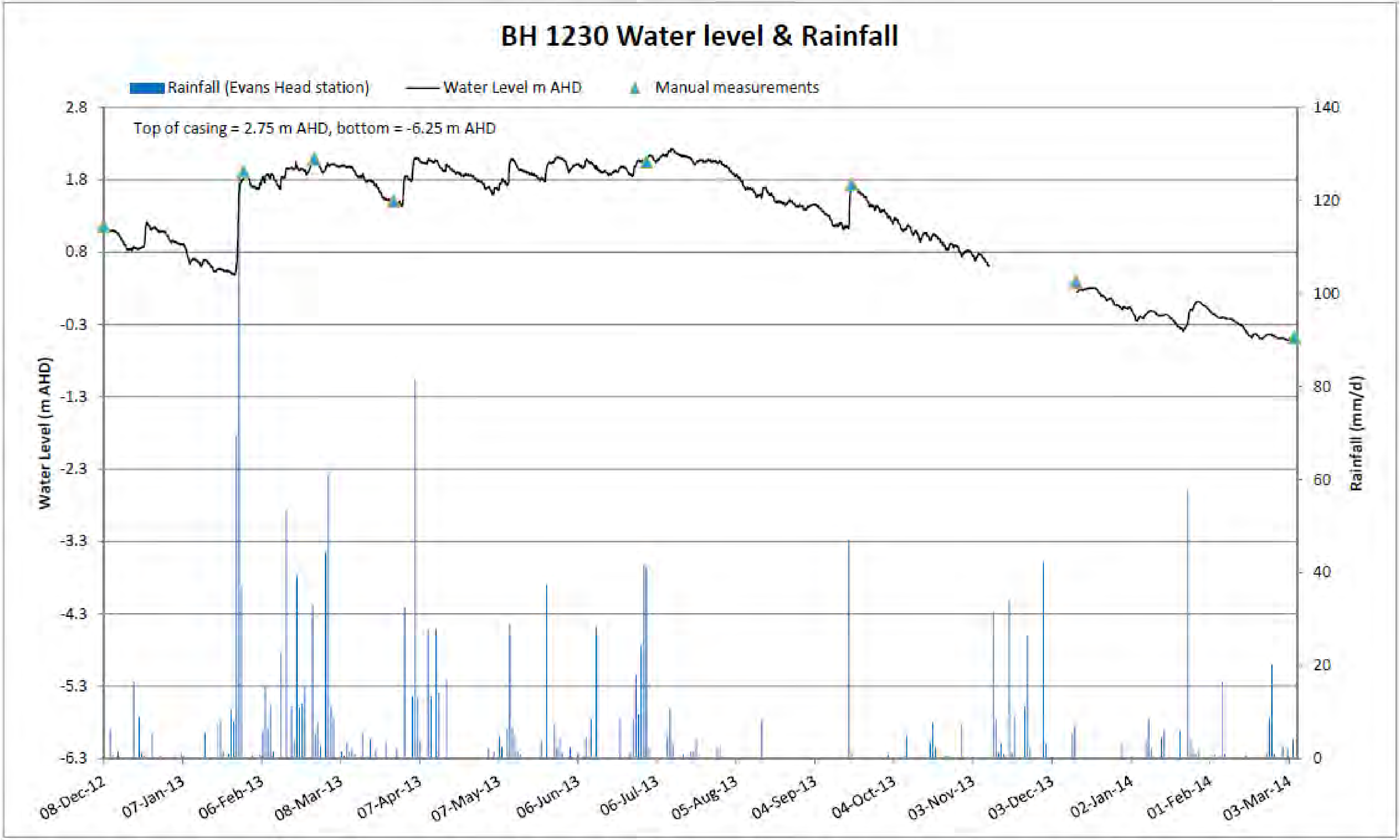
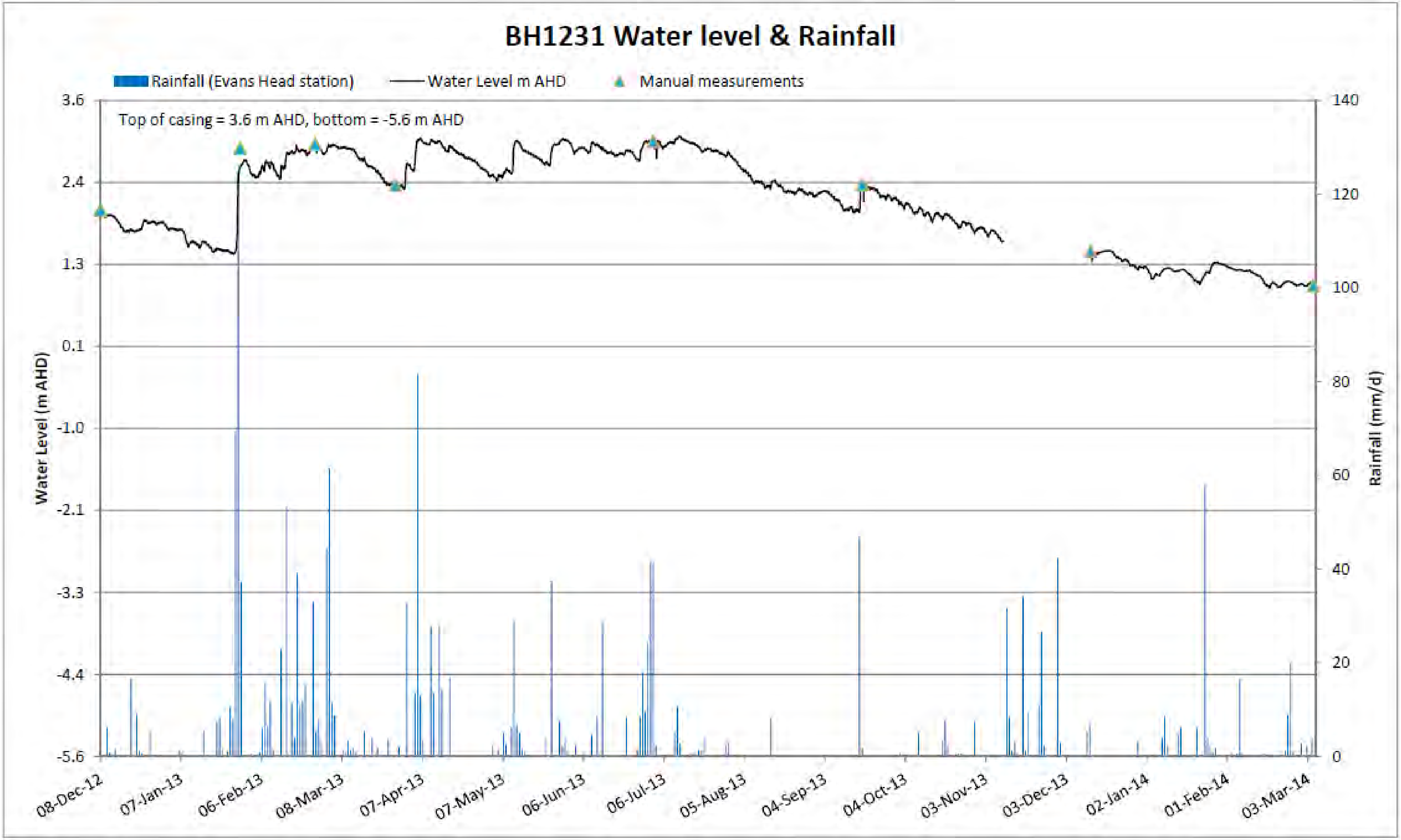
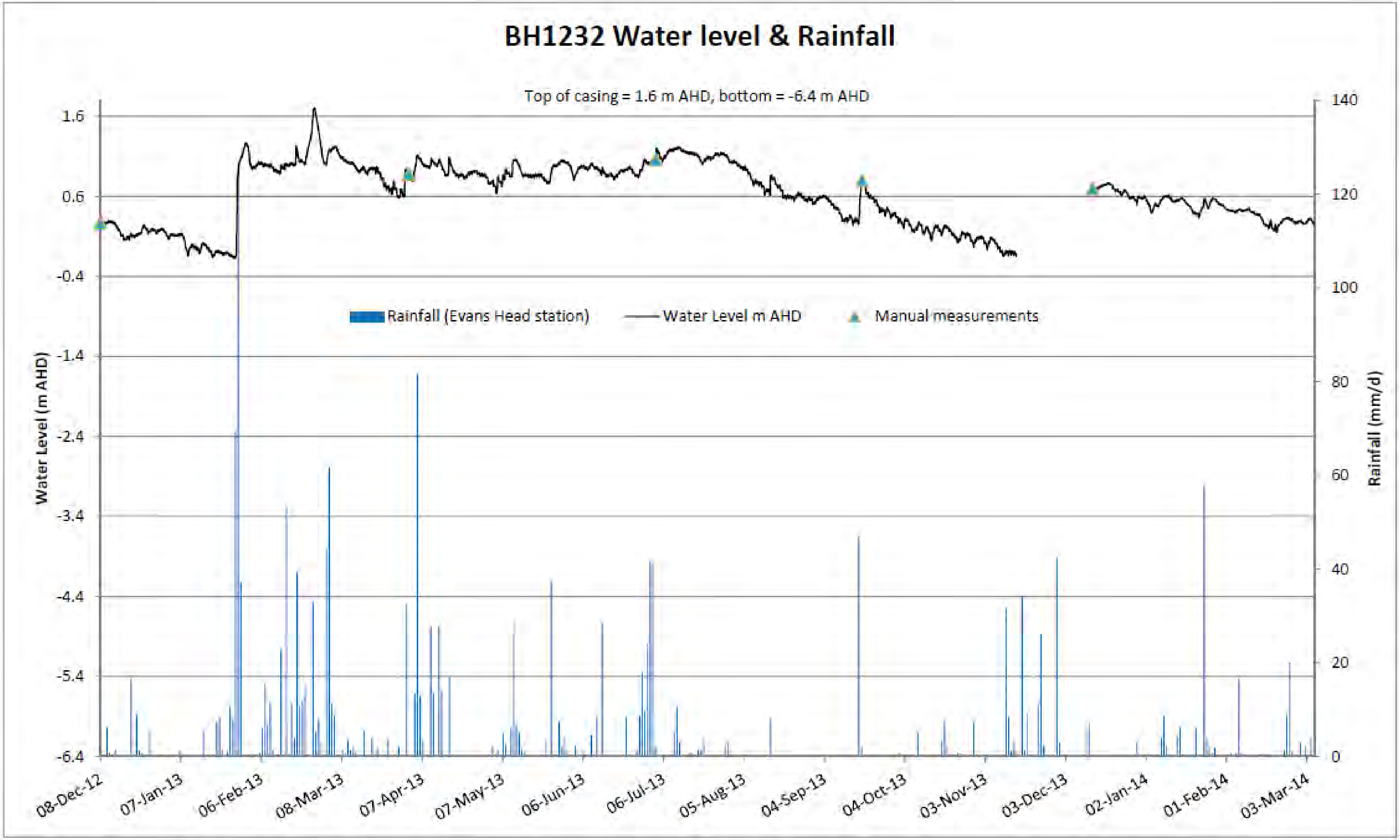
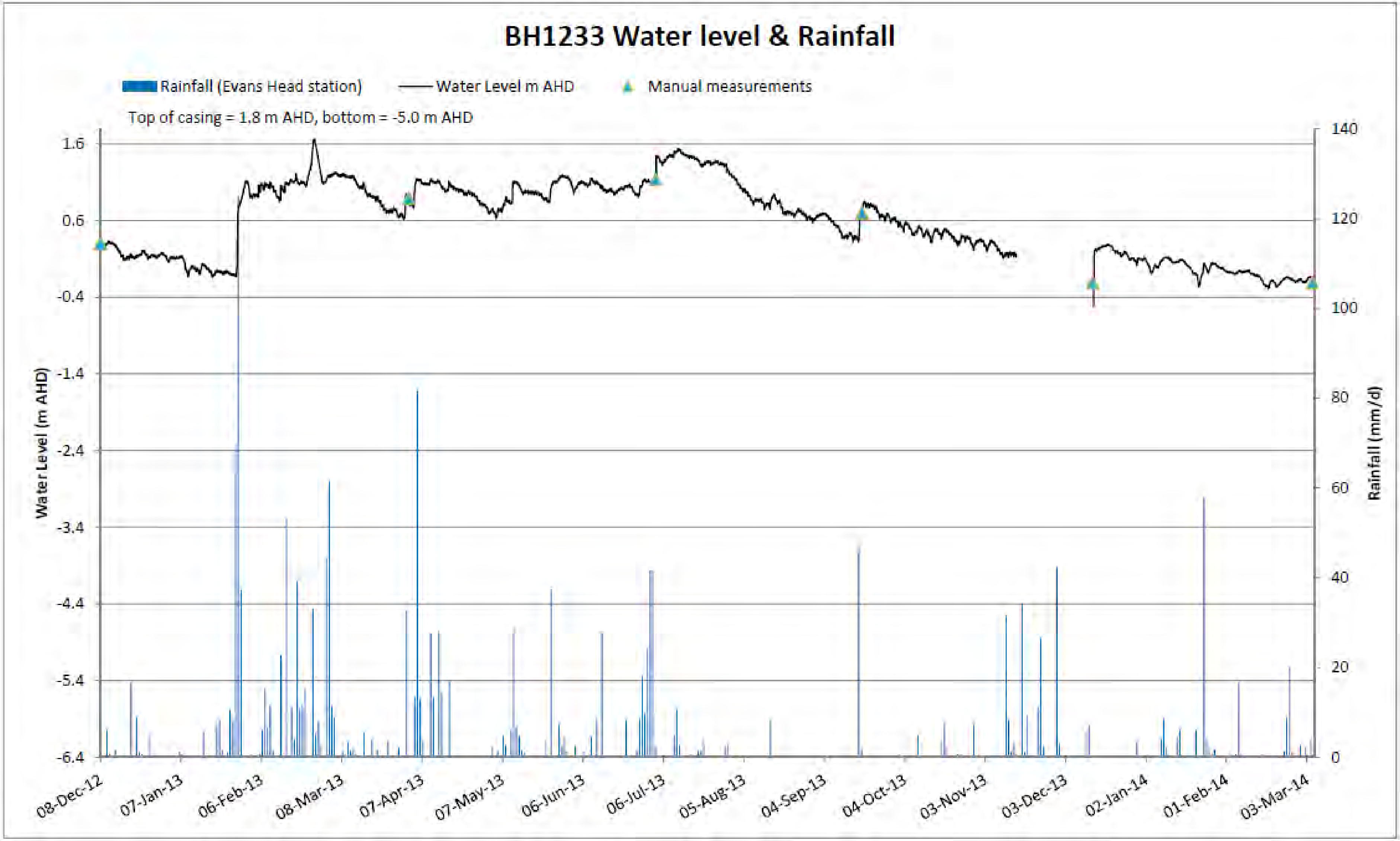
01-Feb-14
03-Mar-14


BH 1230 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.75 m AHD, bottom = -6.25 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.8
1.8
0.8
-0.3
-1.3
-2.3
-3.3
-4.3
-5.3
-6.3
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

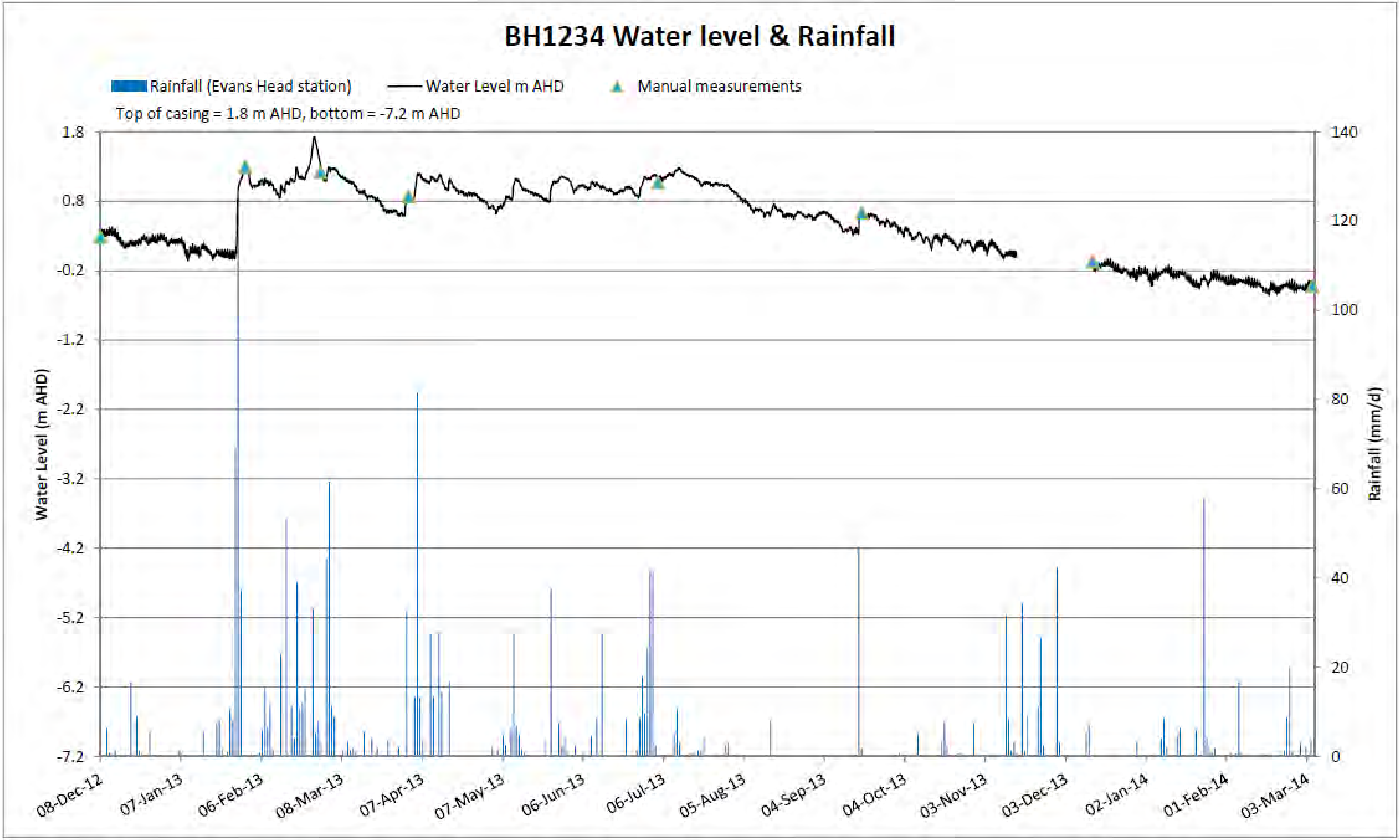

BH1231 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.6 m AHD, bottom = -5.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.6
2.4
1.3
0.1
-1.0
-2.1
-3.3
-4.4
-5.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

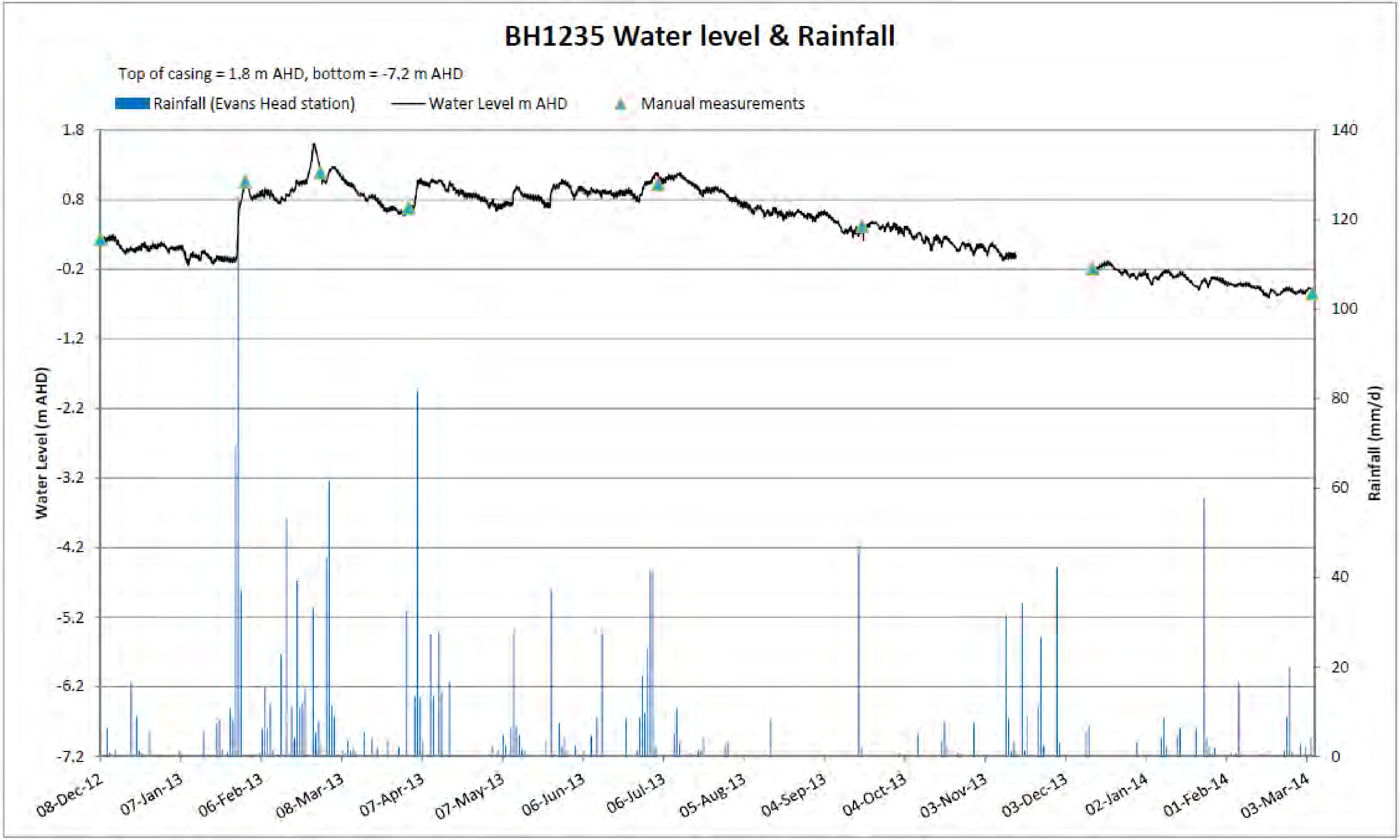


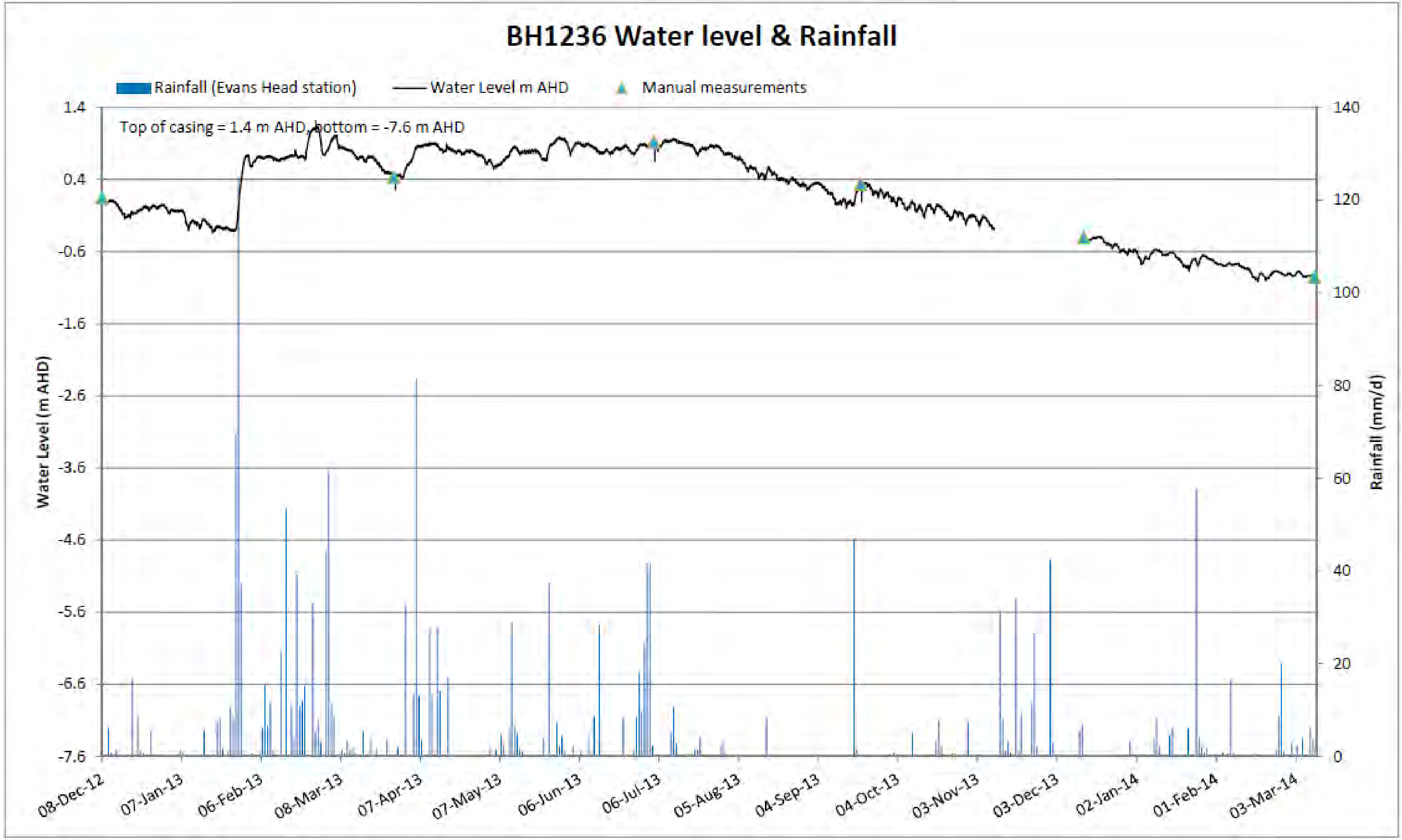
BH1232 Water level & Rainfall
Top of casing = 1.6 m AHD, bottom = -6.4 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

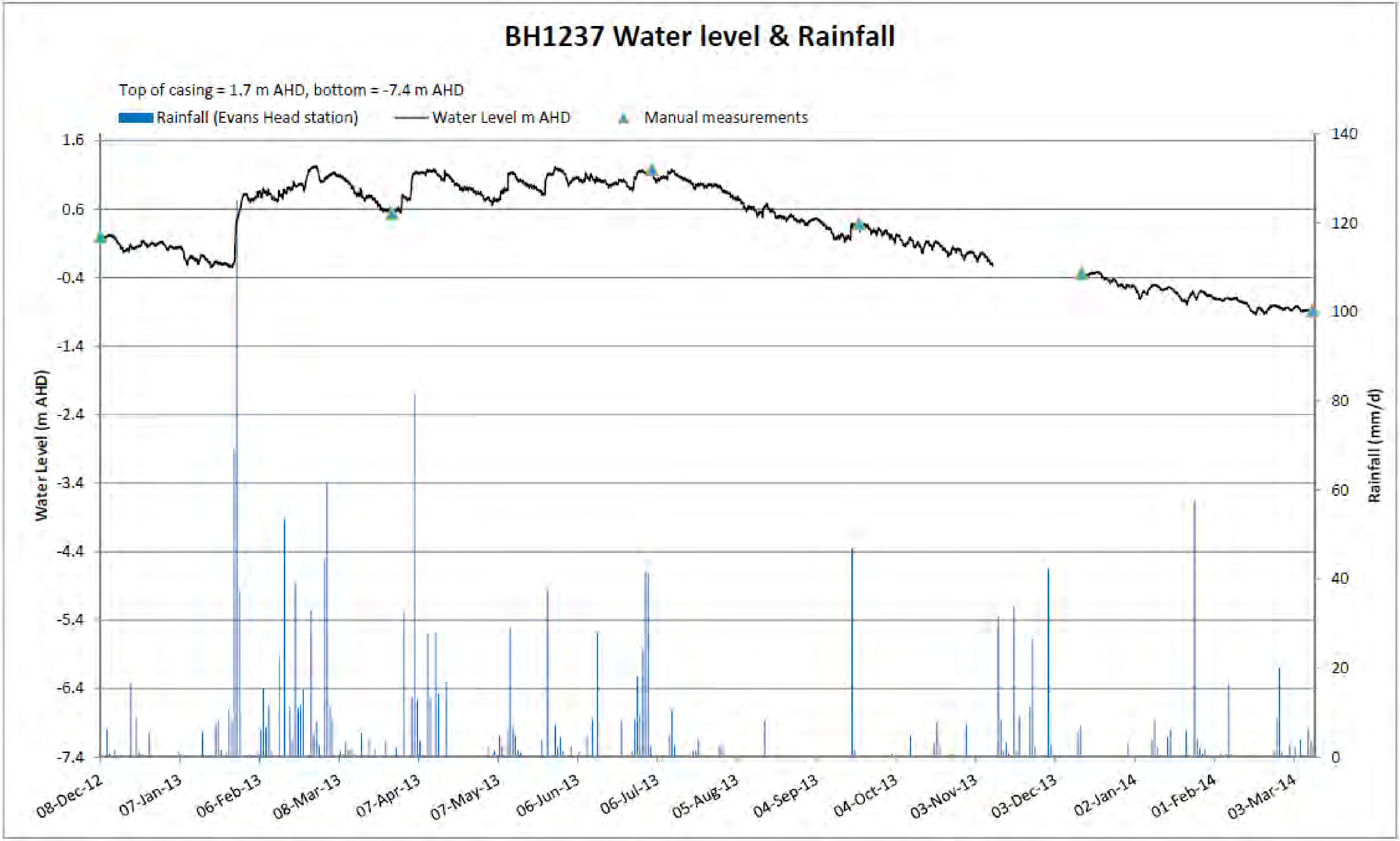


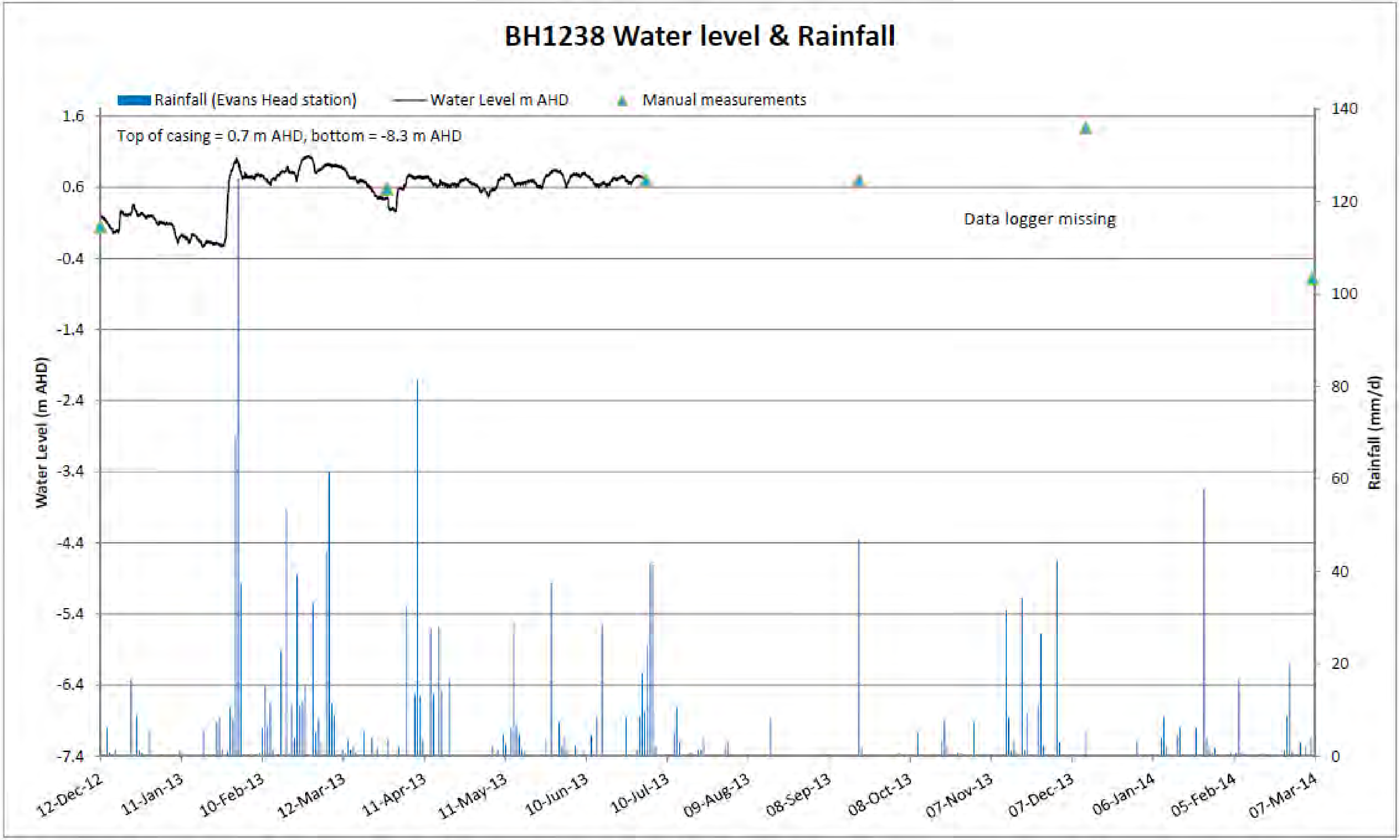
BH1233 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.8 m AHD, bottom = -5.0 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH1234 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.8 m AHD, bottom = -7.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.8
0.8
-0.2
-1.2
-2.2
-3.2
-4.2
-5.2
-6.2
-7.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH1235 Water level & Rainfall
Top of casing = 1.8 m AHD, bottom = -7.2 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
1.8
0.8
-0.2
-1.2
-2.2
-3.2
-4.2
-5.2
-6.2
-7.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH1236 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.4 m AHD, bottom = -7.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.4
0.4
-0.6
-1.6
-2.6
-3.6
-4.6
-5.6
-6.6
-7.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH1237 Water level & Rainfall
Top of casing = 1.7 m AHD, bottom = -7.4 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
-7.4
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH1238 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 0.7 m AHD, bottom = -8.3 m AHD
Data logger missing
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
-7.4
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
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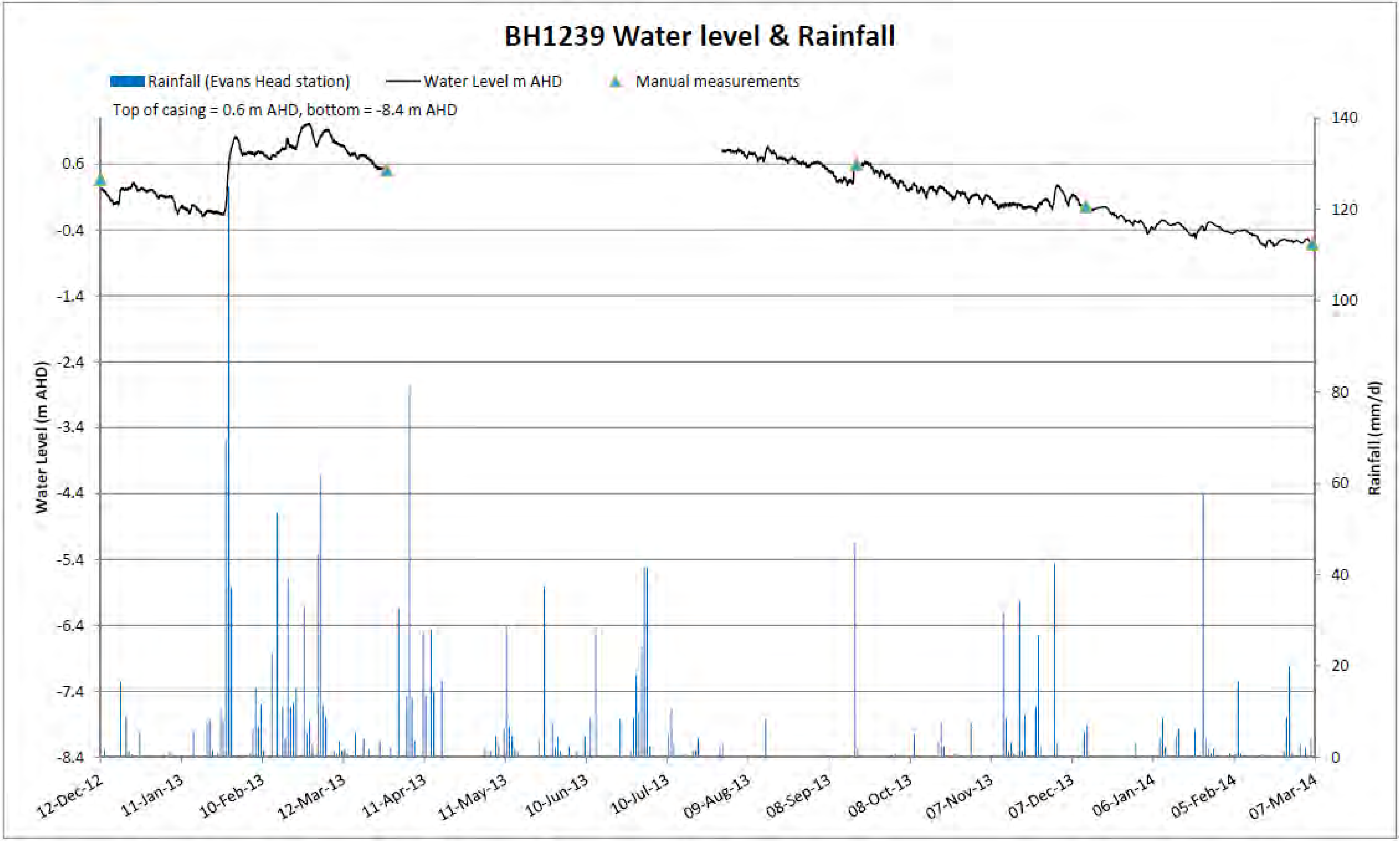
06-Jan-14
05-Feb-14
07-Mar-14



BH1239 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 0.6 m AHD, bottom = -8.4 m AHD
Water Level (m AHD)
Rainfall (mm/d)
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
-7.4
-8.4
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
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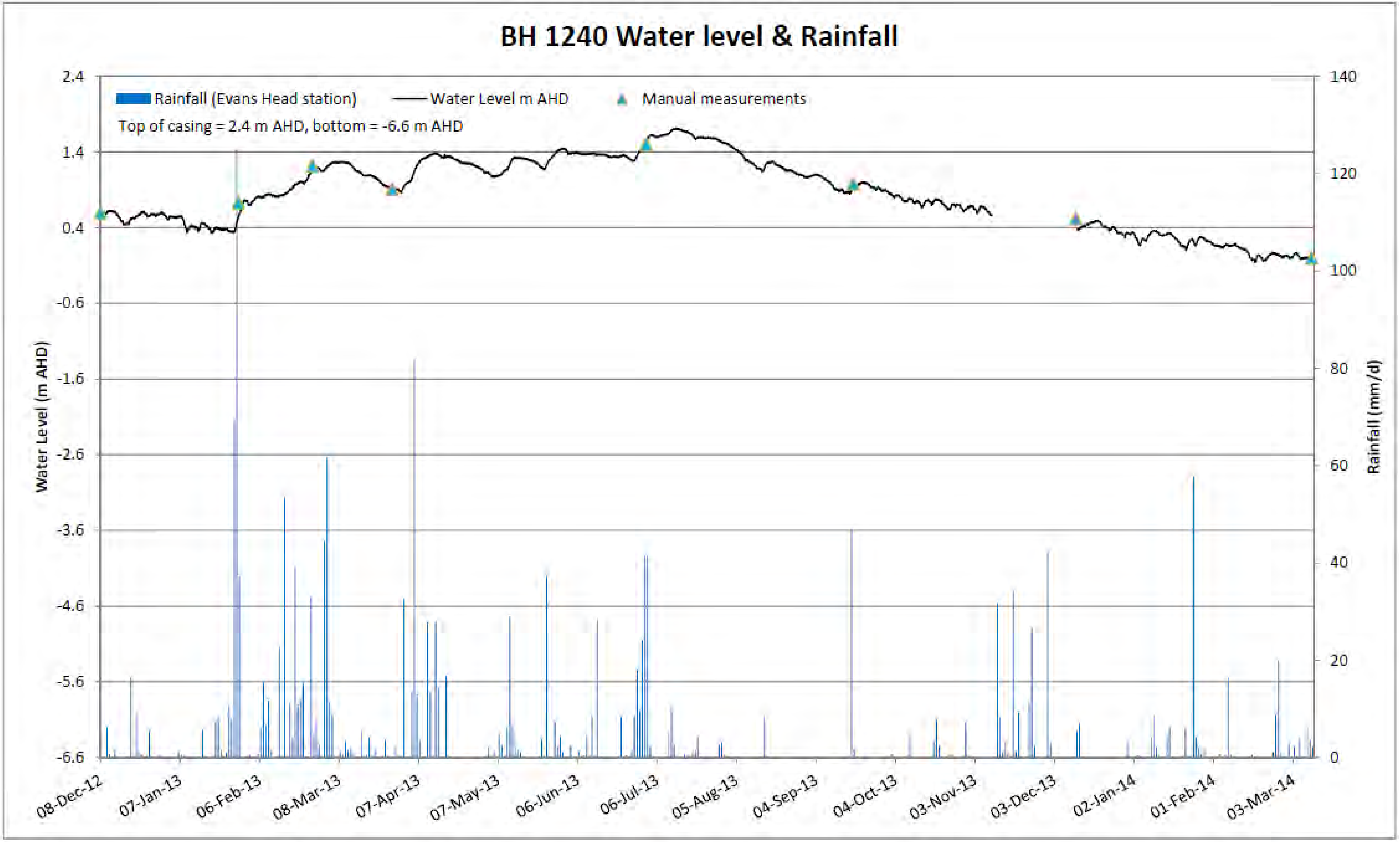
06-Jan-14
05-Feb-14
07-Mar-14


BH 1240 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.4 m AHD, bottom = -6.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.4
1.4
0.4
-0.6
-1.6
-2.6
-3.6
-4.6
-5.6
-6.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
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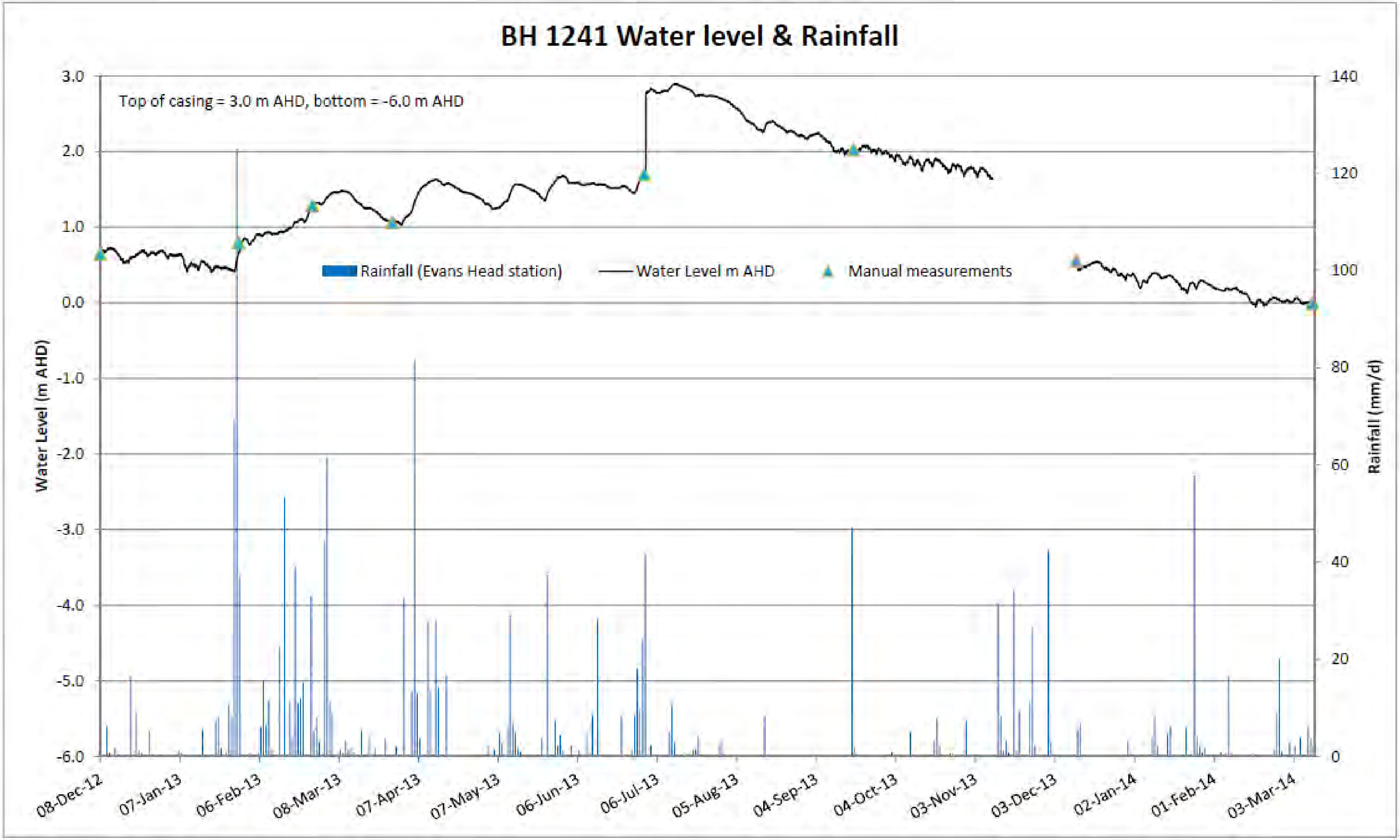
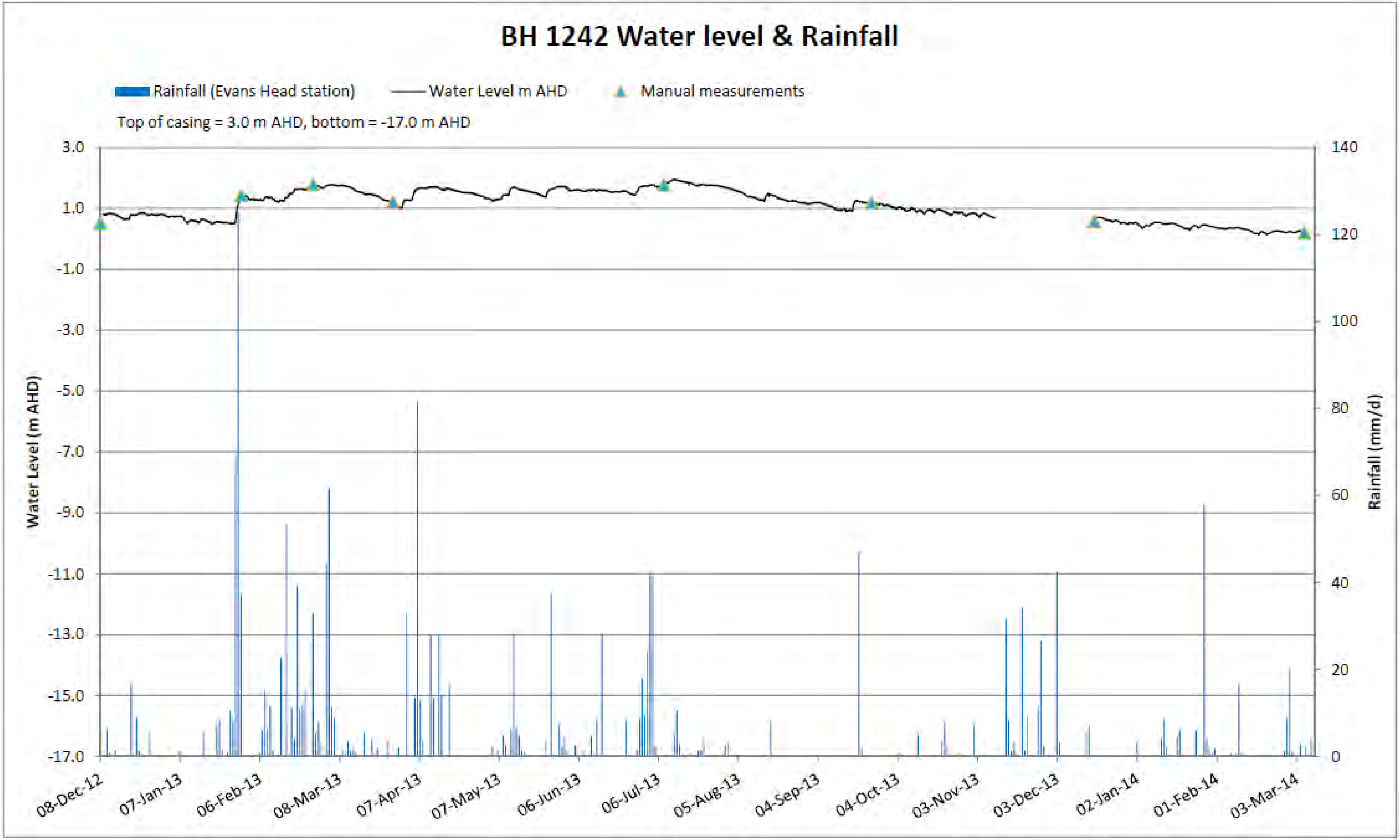
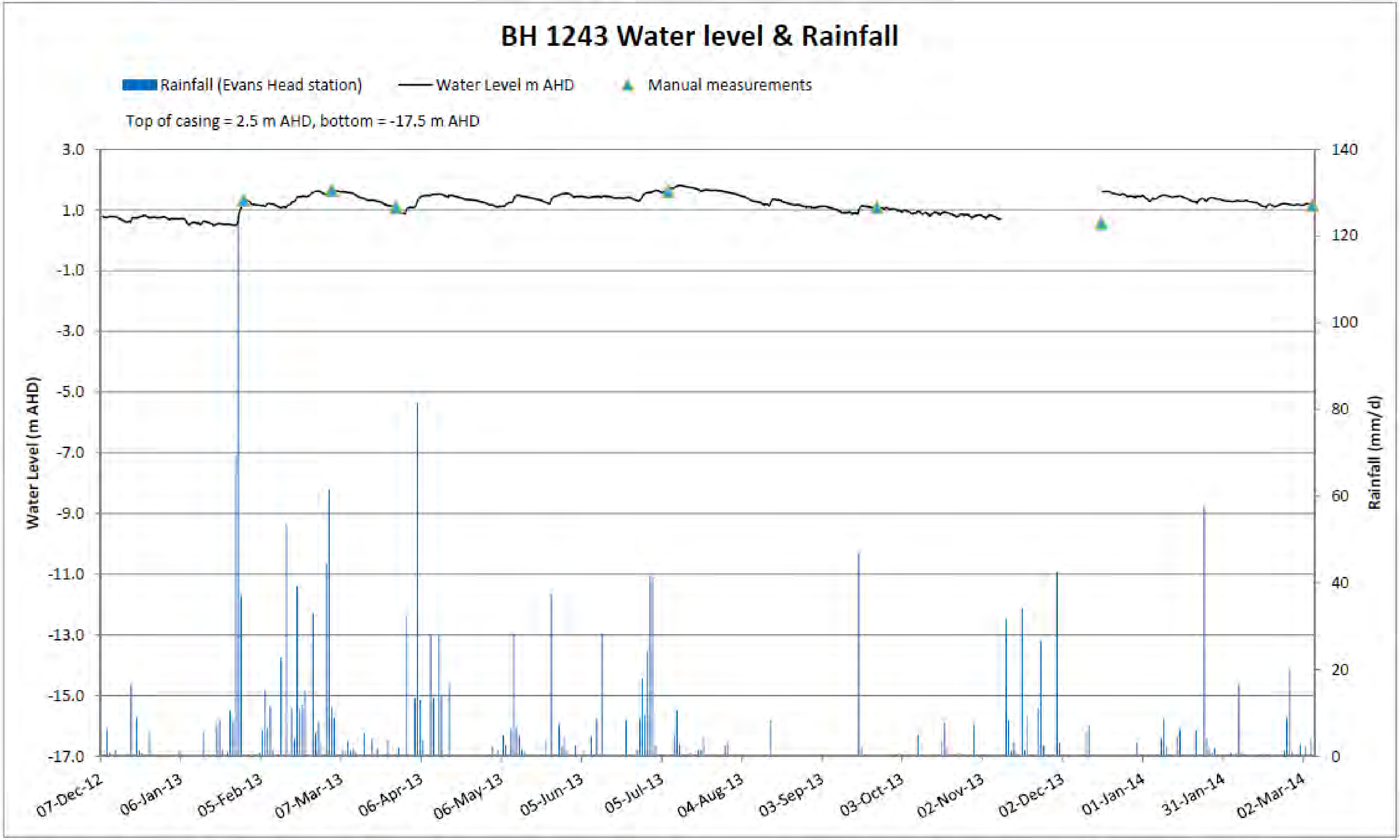
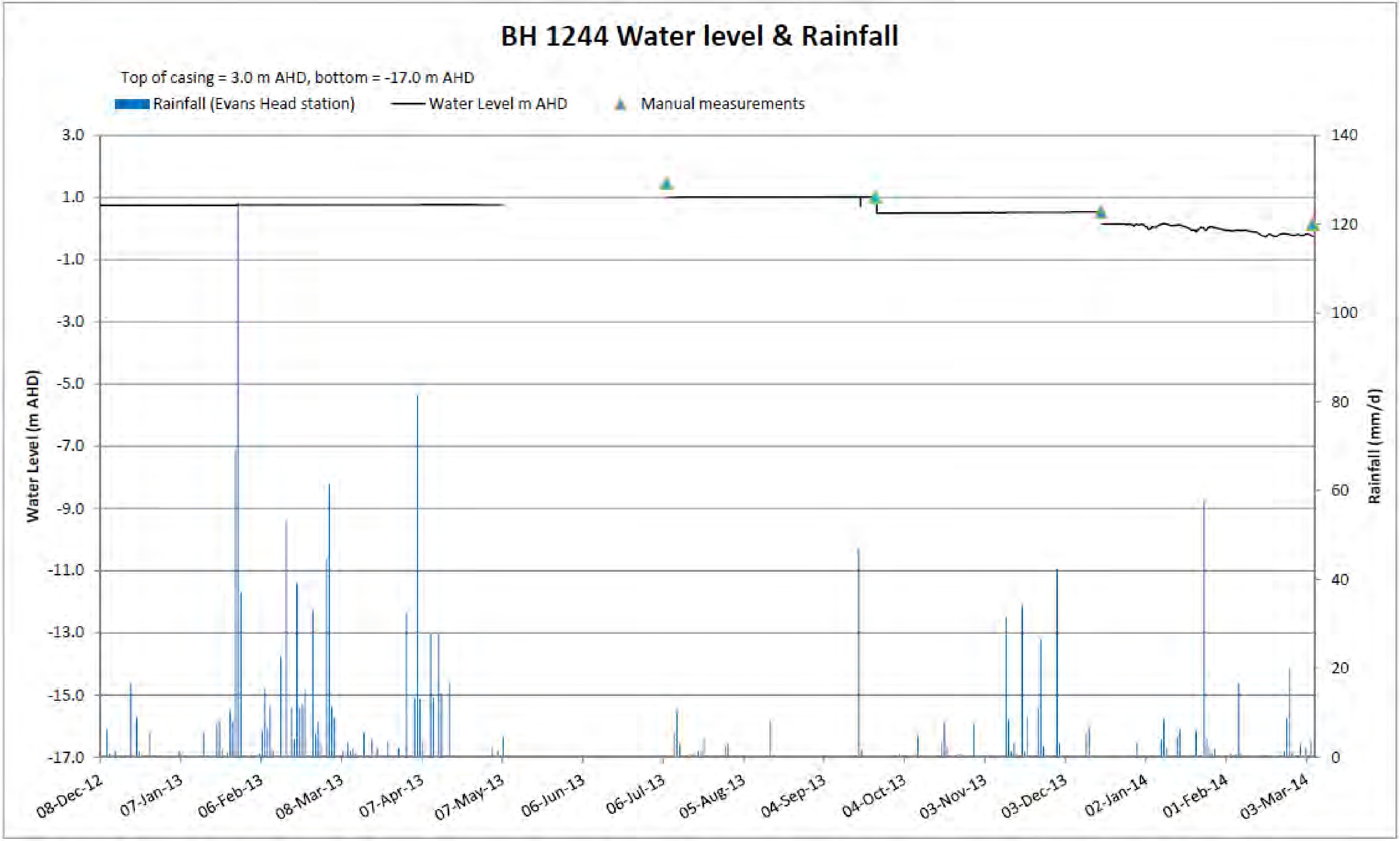
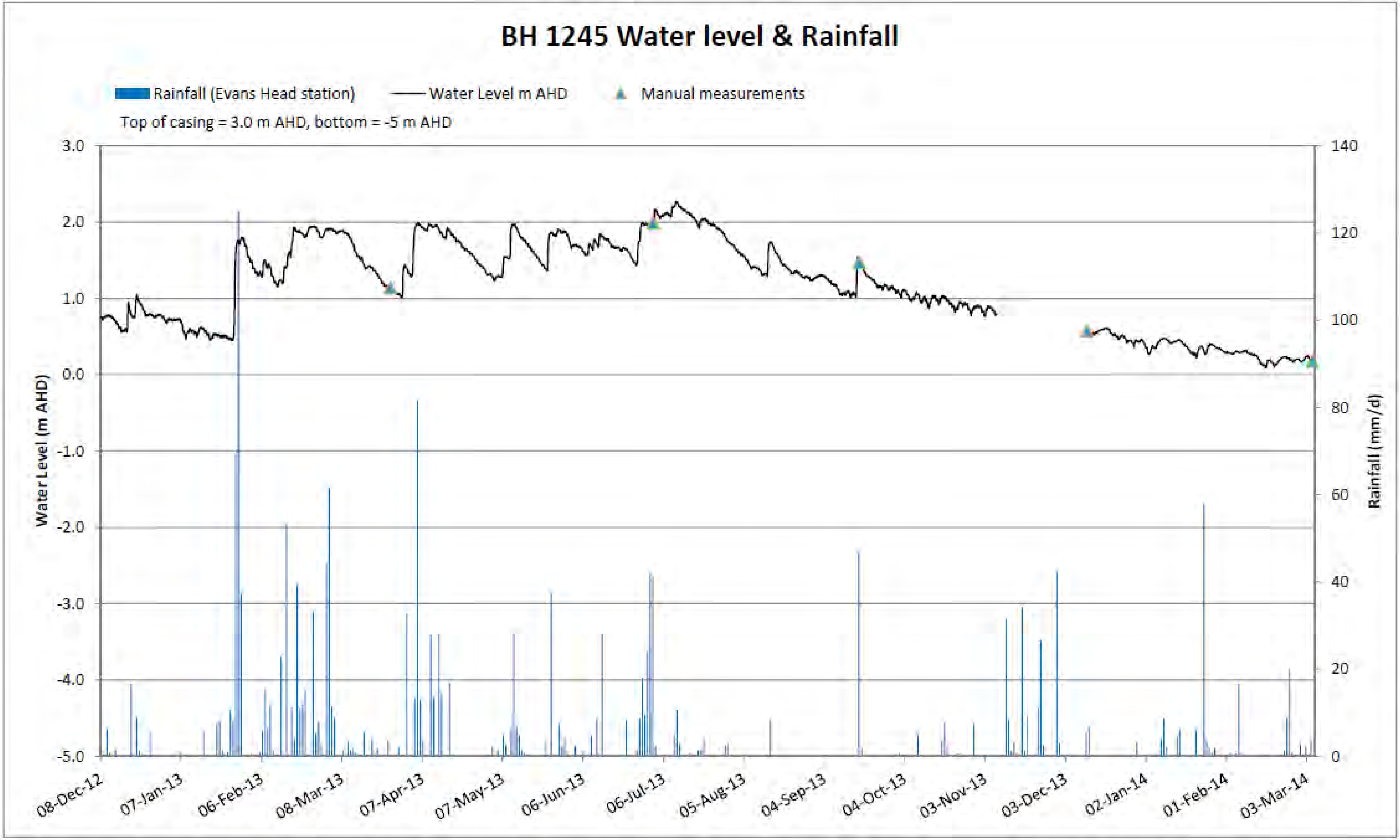
01-Feb-14
03-Mar-14


BH 1241 Water level & Rainfall
Top of casing = 3.0 m AHD, bottom = -6.0 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

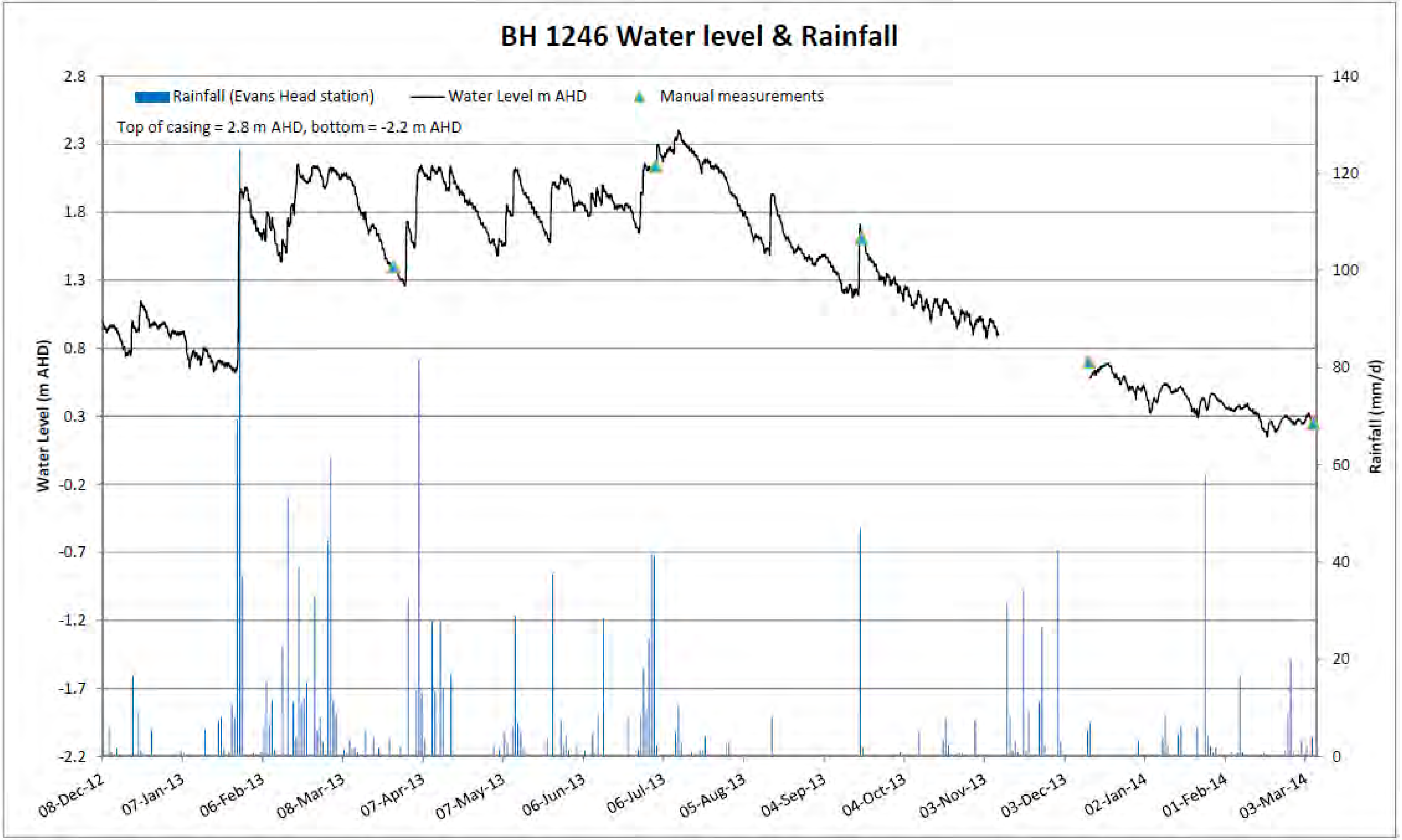

BH 1242 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.0 m AHD, bottom = -17.0 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
1.0
-1.0
-3.0
-5.0
-7.0
-9.0
-11.0
-13.0
-15.0
-17.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

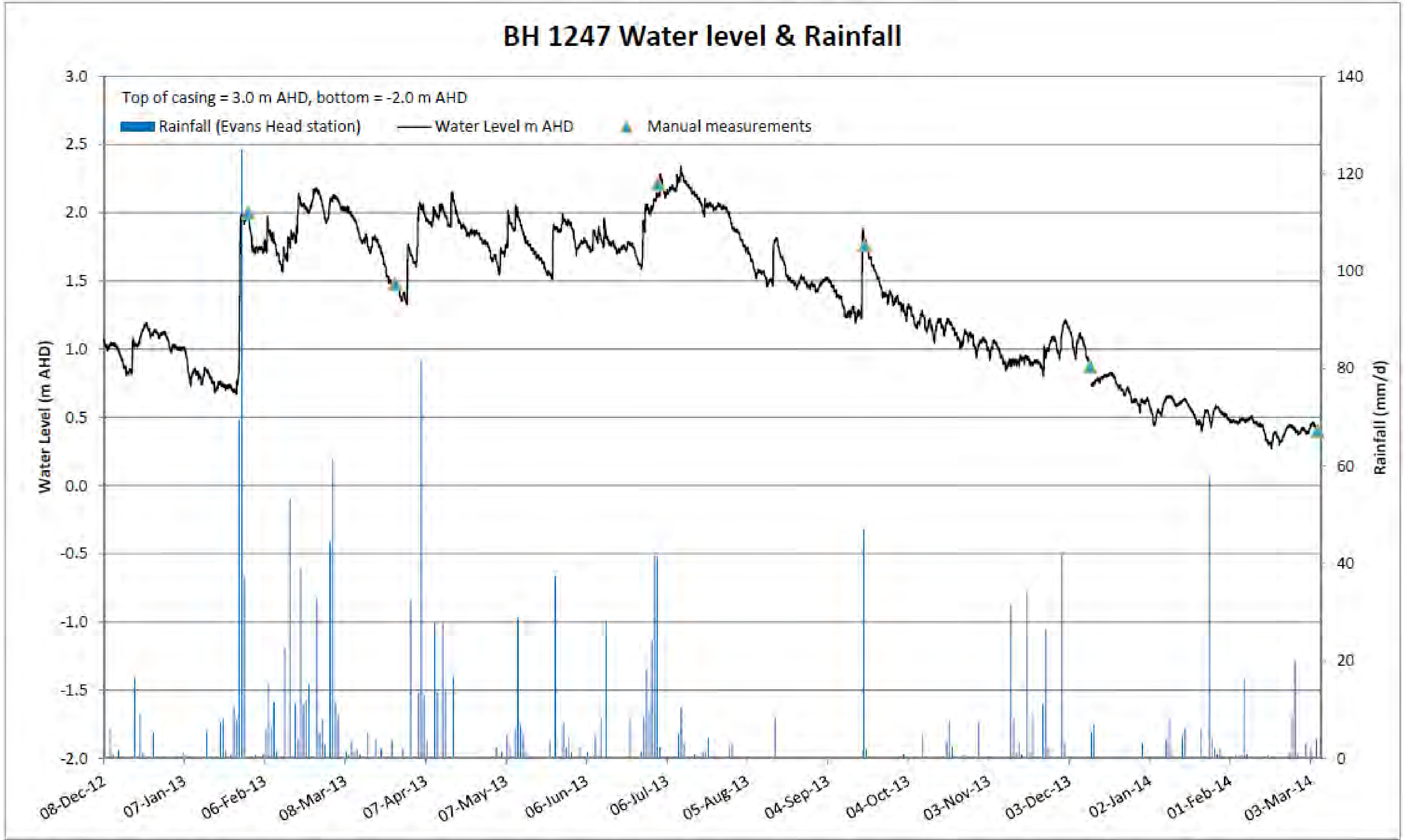

BH 1243 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.5 m AHD, bottom = -17.5 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
1.0
-1.0
-3.0
-5.0
-7.0
-9.0
-11.0
-13.0
-15.0
-17.0
140
120
100
80
60
40
20
0
07-Dec-12
06-Jan-13
05-Feb-13
07-Mar-13
06-Apr-13
06-May-13
05-Jun-13
05-Jul-13
04-Aug-13
03-Sep-13
03-Oct-13
02-Nov-13
02-Dec-13
01-Jan-14
31-Jan-14
02-Mar-14


BH 1244 Water level & Rainfall
Top of casing = 3.0 m AHD, bottom = -17.0 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.0
1.0
-1.0
-3.0
-5.0
-7.0
-9.0
-11.0
-13.0
-15.0
-17.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

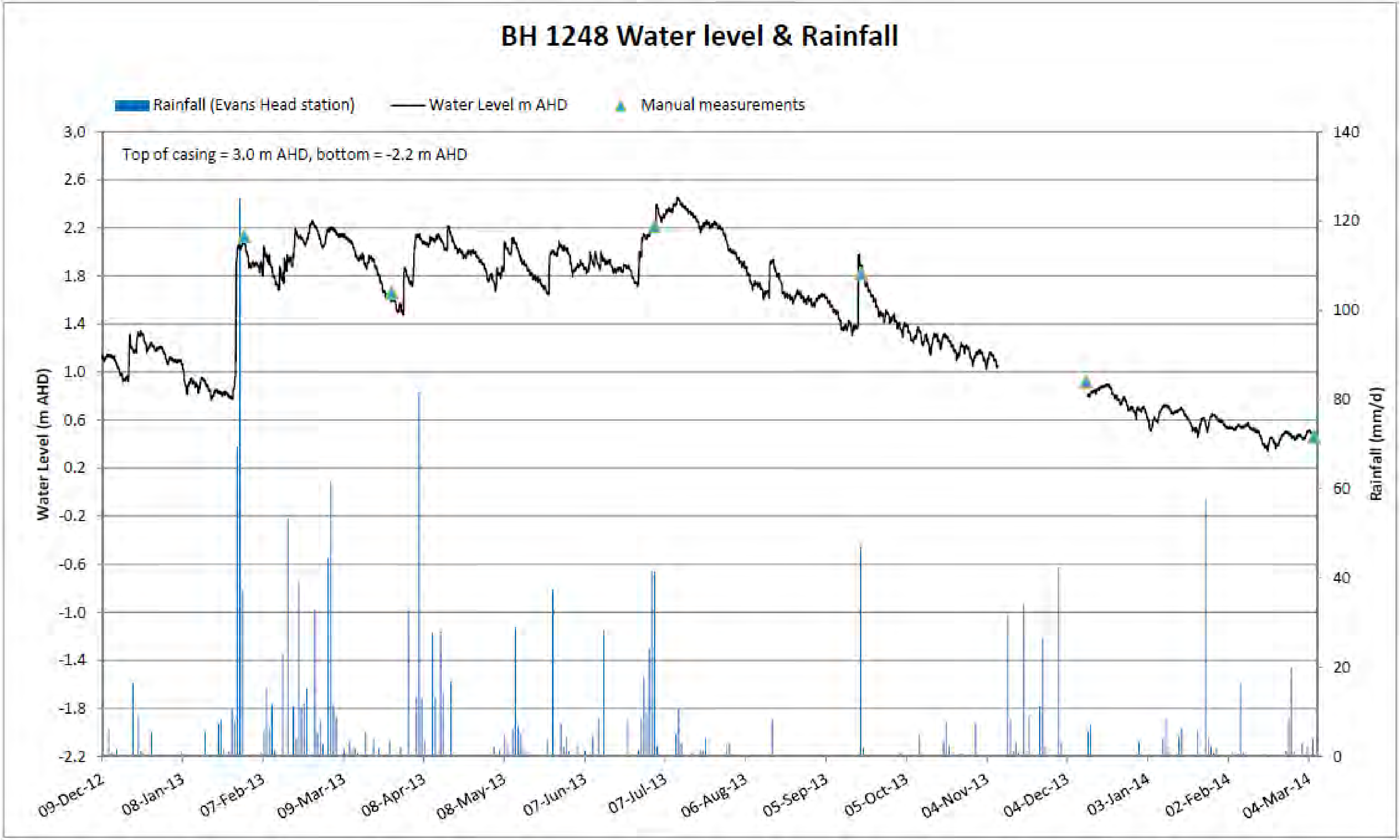


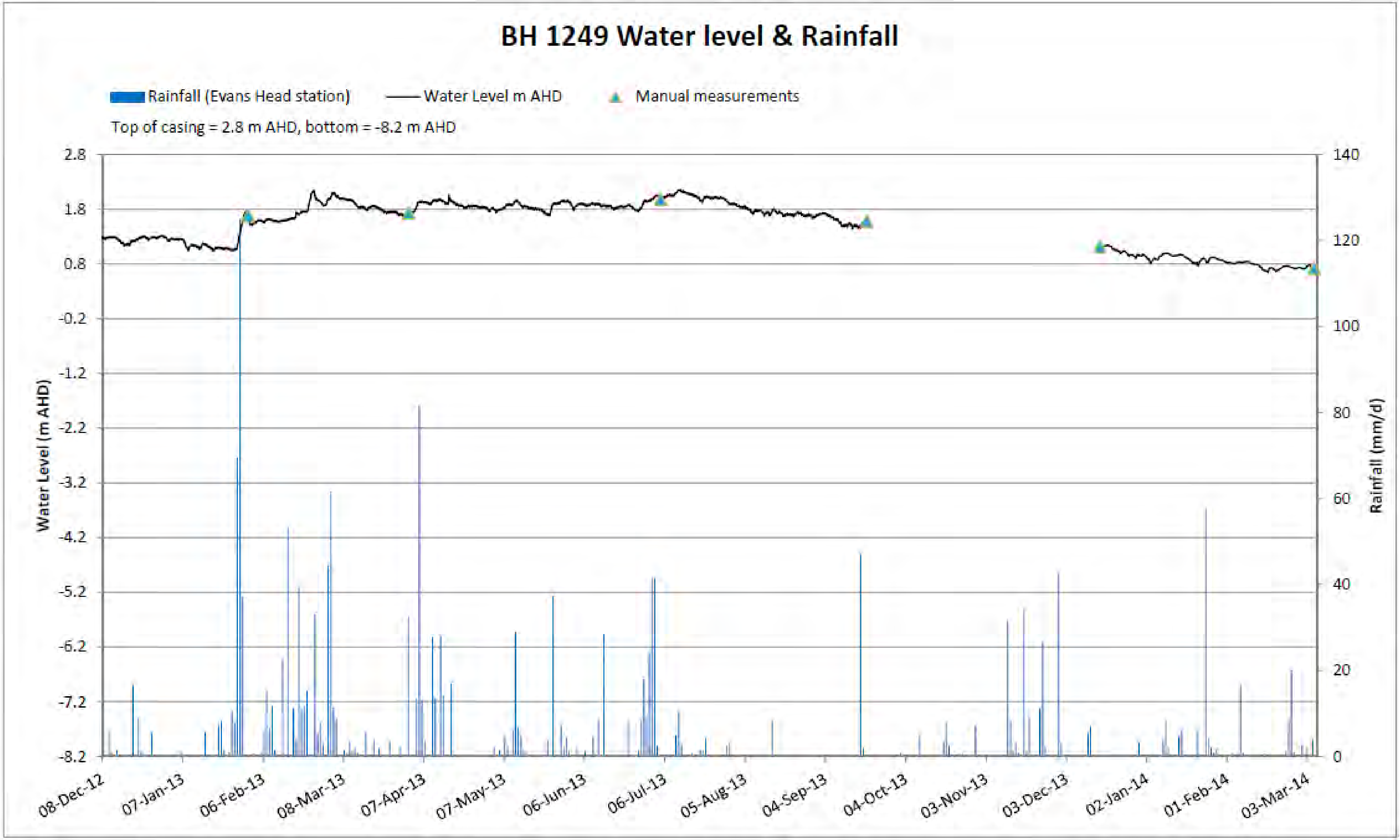
BH 1245 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.0 m AHD, bottom = -5 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1246 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.8 m AHD, bottom = -2.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.8
2.3
1.8
1.3
0.8
0.3
-0.2
-0.7
-1.2
-1.7
-2.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14



BH 1247 Water level & Rainfall
Top of casing = 3.0 m AHD, bottom = -2.0 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1248 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.0 m AHD, bottom = -2.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.6
2.2
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-2.2
140
120
100
80
60
40
20
0
09-Dec-12
08-Jan-13
07-Feb-13
09-Mar-13
08-Apr-13
08-May-13
07-Jun-13
07-Jul-13
06-Aug-13
05-Sep-13
05-Oct-13
04-Nov-13
04-Dec-13
03-Jan-14
02-Feb-14
04-Mar-14


BH 1249 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.8 m AHD, bottom = -8.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.8
1.8
0.8
-0.2
-1.2
-2.2
-3.2
-4.2
-5.2
-6.2
-7.2
-8.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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03-Nov-13
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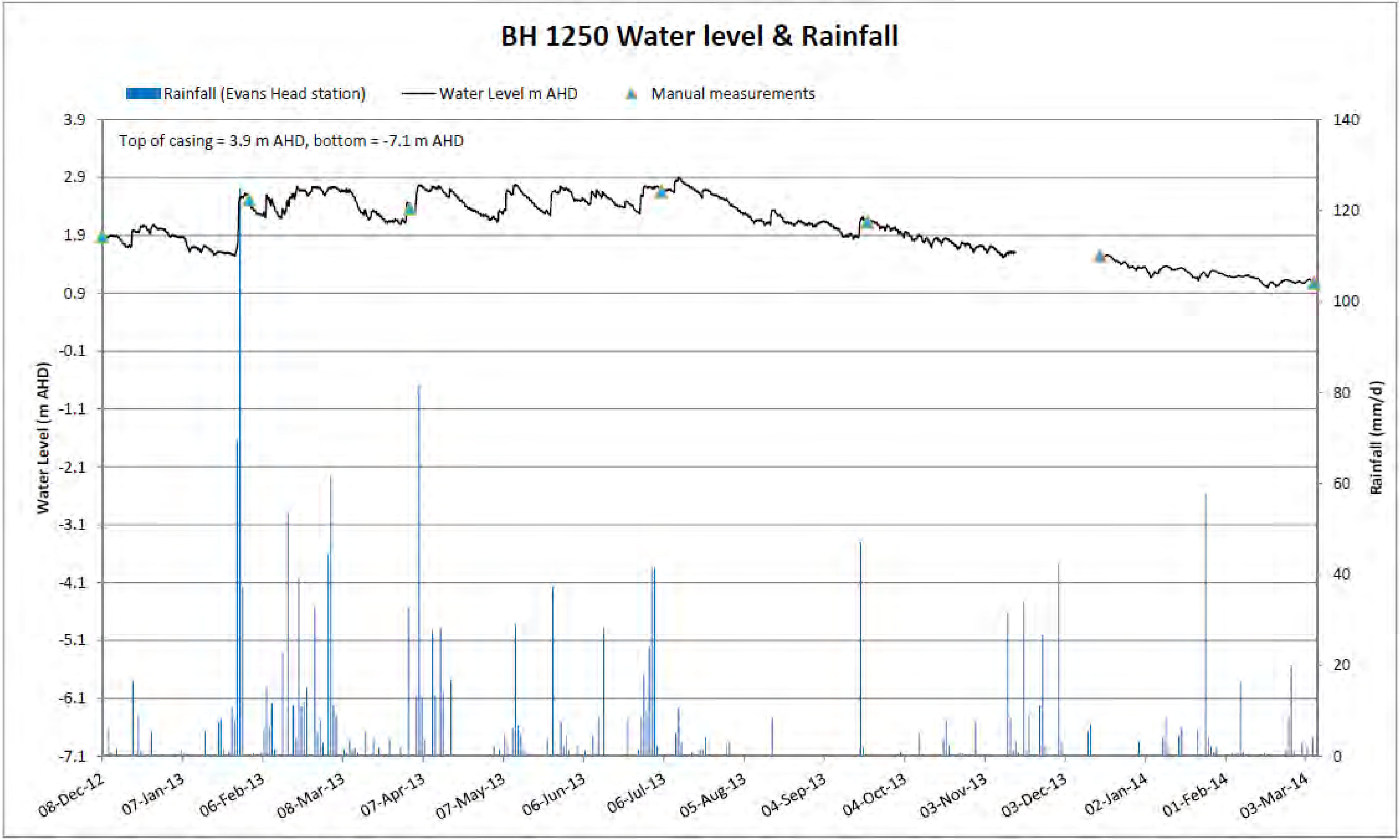
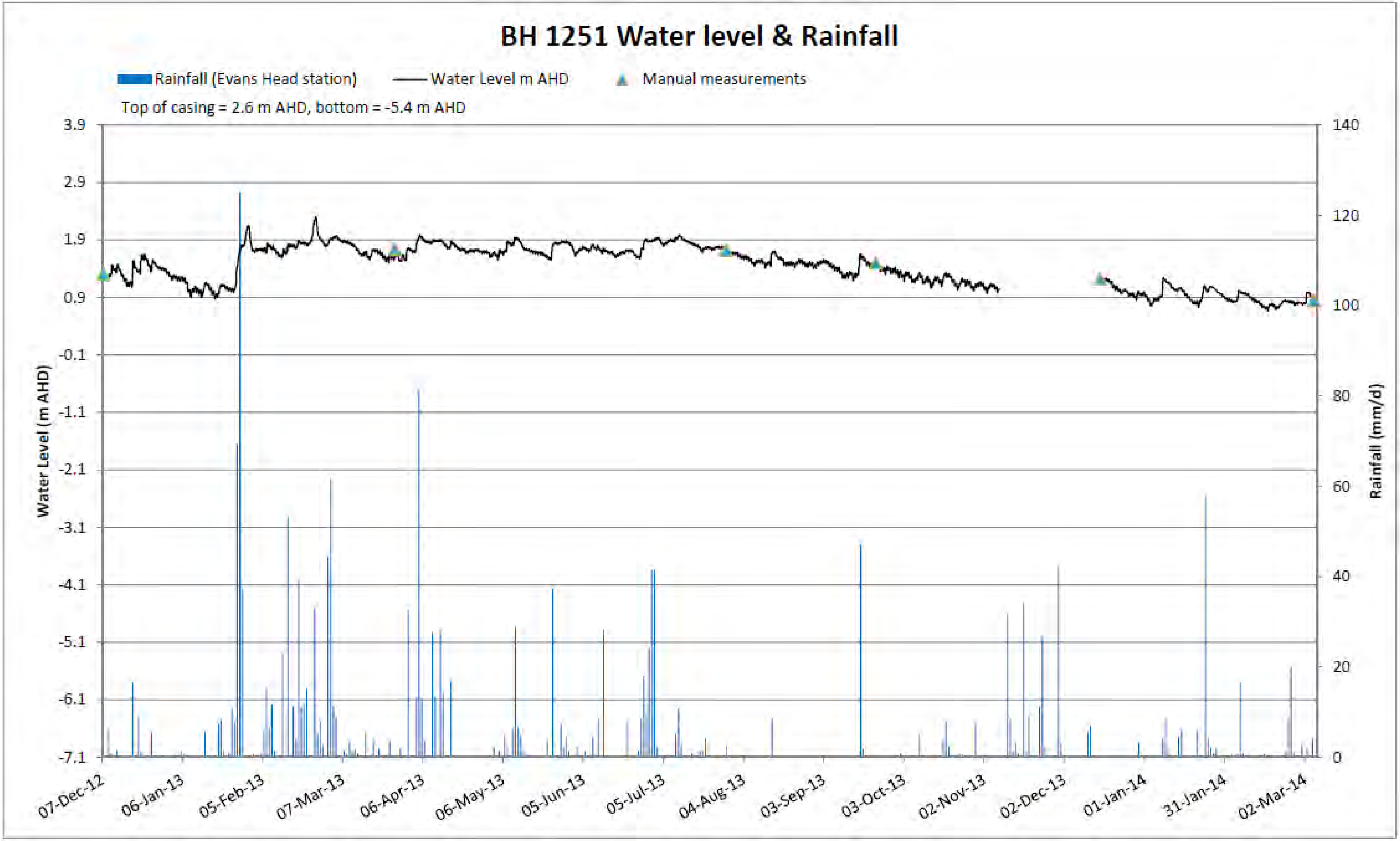
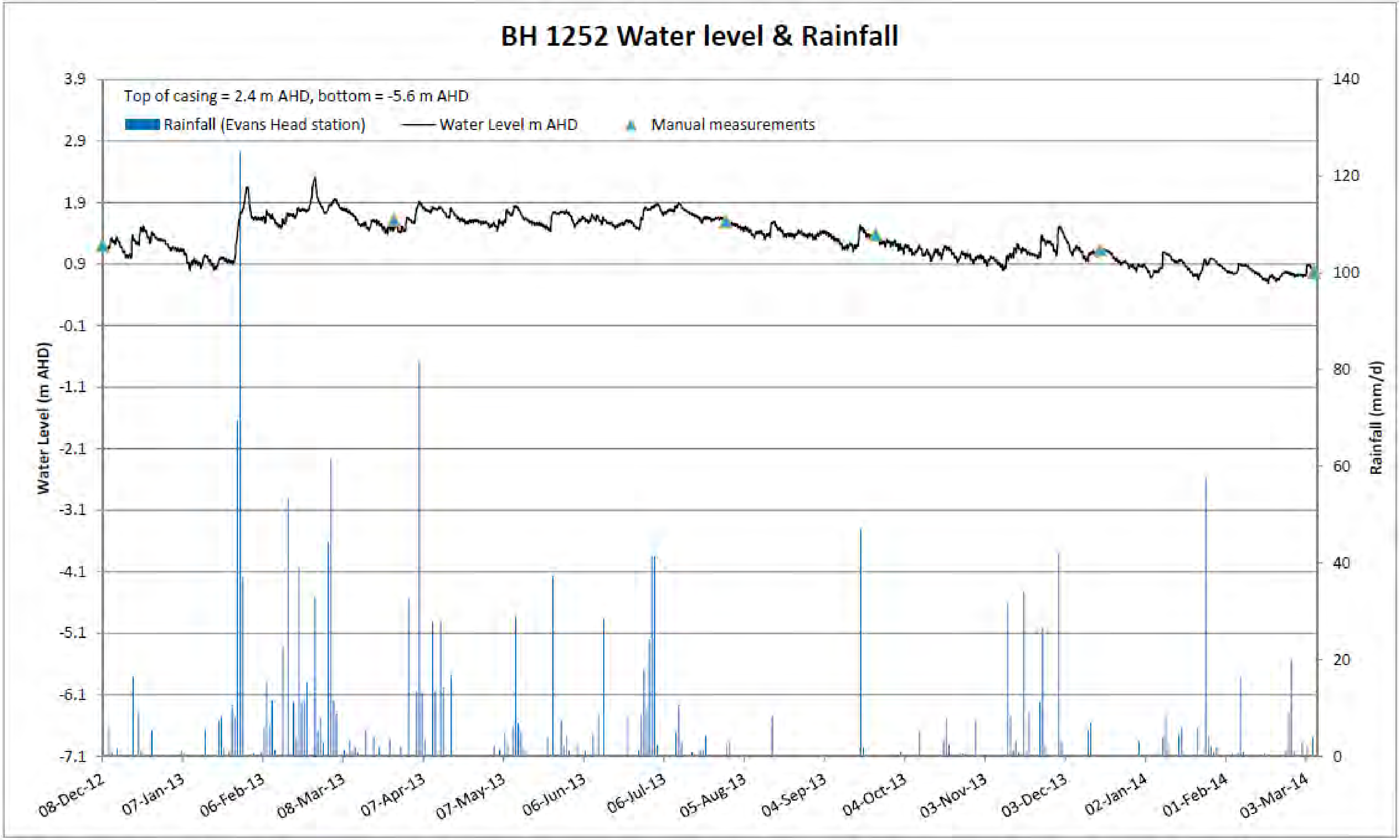
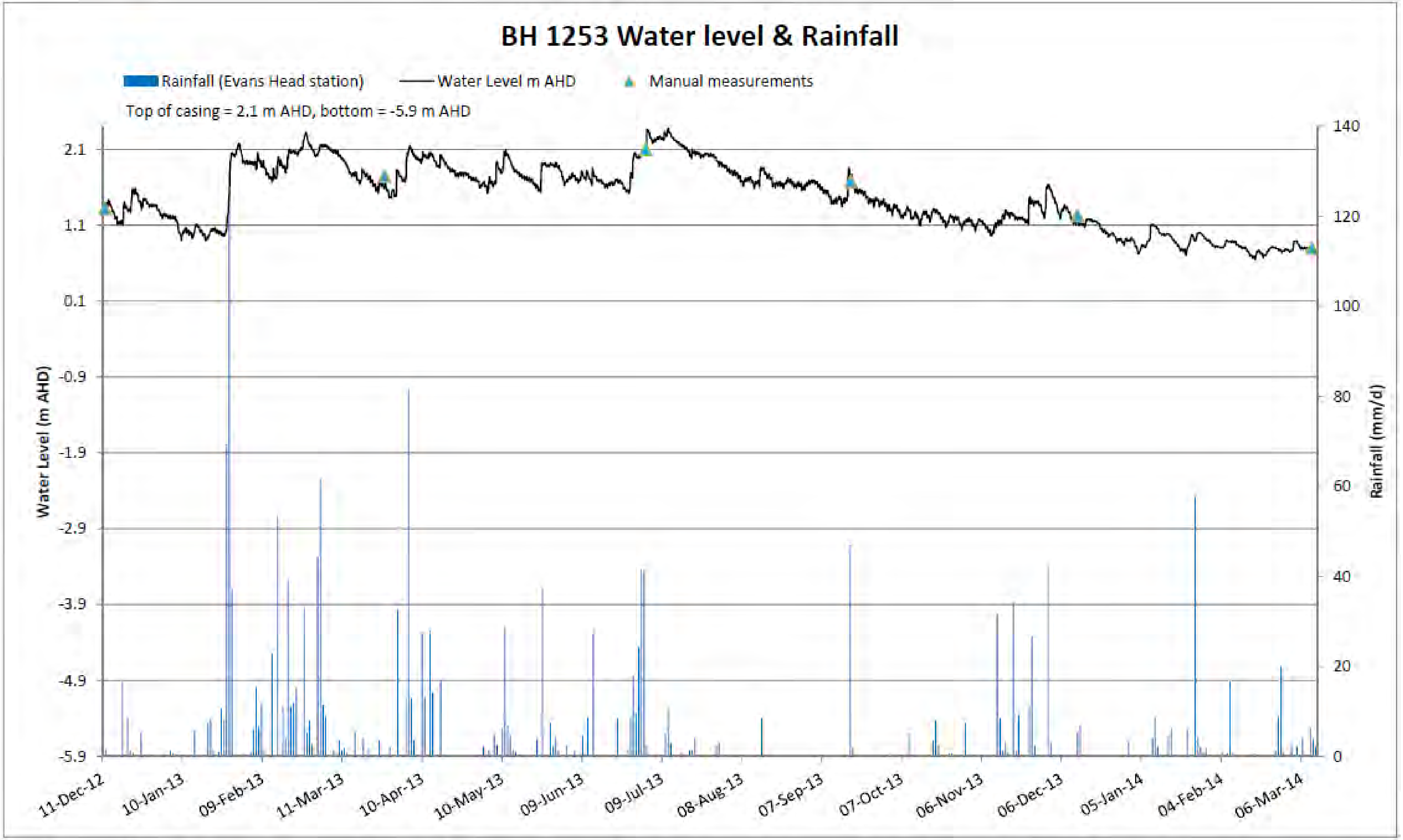
02-Jan-14
01-Feb-14
03-Mar-14


BH 1250 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.9 m AHD, bottom = -7.1 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.9
2.9
1.9
0.9
-0.1
-1.1
-2.1
-3.1
-4.1
-5.1
-6.1
-7.1
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1251 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.6 m AHD, bottom = -5.4 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.9
2.9
1.9
0.9
-0.1
-1.1
-2.1
-3.1
-4.1
-5.1
-6.1
-7.1
140
120
100
80
60
40
20
0
07-Dec-12
06-Jan-13
05-Feb-13
07-Mar-13
06-Apr-13
06-May-13
05-Jun-13
05-Jul-13
04-Aug-13
03-Sep-13
03-Oct-13
02-Nov-13
02-Dec-13
01-Jan-14
31-Jan-14
02-Mar-14


BH 1252 Water level & Rainfall
Top of casing = 2.4 m AHD, bottom = -5.6 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.9
2.9
1.9
0.9
-0.1
-1.1
-2.1
-3.1
-4.1
-5.1
-6.1
-7.1
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1253 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.1 m AHD, bottom = -5.9 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.1
1.1
0.1
-0.9
-1.9
-2.9
-3.9
-4.9
-5.9
140
120
100
80
60
40
20
0
11-Dec-12
10-Jan-13
09-Feb-13
11-Mar-13
10-Apr-13
10-May-13
09-Jun-13
09-Jul-13
08-Aug-13
07-Sep-13
07-Oct-13
06-Nov-13
06-Dec-13
05-Jan-14
04-Feb-14
06-Mar-14

Appendix H

Section 9 - Broadwater National Park to Richmond River: Pre-Construction Monitoring Results

Section 9: Surface Water Monitoring Locations and associated Sensitive Receiving Environments

Surface Water Sample Locations / Waterway	*Sensitive aquatic receiving environments and groundwater dependent ecosystems (GDE's)*
SW09 - Montis Gully SW10 - Everson's Creek	▪ No significant sensitive receiving environment ▪ No significant sensitive receiving environment

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 9: Surface Water Monitoring – Overview of Results

Physical properties

Temperature generally exhibited a gradual increase generally from the mid-teens (15-17°C) in winter up to the high-20s (27-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. pH levels fell within the range of 4.0 to 7.0.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were within the range of <0.01 to 2.46 mg/L. Total Nitrogen values were found to be in the range of 0.3 to 4.2 mg/L.

Heavy metals

No testing for heavy metals was conducted.

Summary of Visual Observations and Sampling Results

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW09 Montis Gully Ch. 140,950	▪ No record of visual observations provided.	▪ O&G: <5-23mg/L ▪ SS: 5-165mg/L ▪ TP: <0.01-0.32mg/L ▪ TN: 0.3-1.5mg/L ▪ DO: 2.1-9.4mg/L ▪ EC: 98-170µS/cm ▪ pH: 4.0-7.0 ▪ Temp: 17.6-30.9ºC ▪ NTU: 1.1-31.0

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW10 Everson's Creek Ch. 143,400	▪ As above.	▪ O&G: <5-5mg/L ▪ SS: <5-255mg/L ▪ TP: 0.26-2.46mg/L ▪ TN: 1.4-4.2mg/L ▪ DO: 1.0-10.7mg/L ▪ EC: 128-288µS/cm ▪ pH: 4.5-5.7 ▪ Temp: 15.3-27.4ºC ▪ NTU: 2.1-42

Note: * Ch. = Highway Chainage

Section 9: Surface Water Monitoring – Sampling Statistics

	Units	**SECTION 9**							
SW09 (SW9-01 and SW9-02)									
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	4.21	5.92	23.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	48.08	55.05	165.00	5.0	17.0	91.6	-	
Total Phosphorus as P	mg/l	0.09	0.08	0.32	0.0	0.1	0.106	-	
Total Nitrogen as N	mg/l	0.74	0.33	1.50	0.3	0.7	0.9	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.73	2.69	9.40	2.1	7.9	8.66	3.7	
Conductivity	µs/cm	97.93	35.33	159.00	26.0	98.5	116.56	79.4	
pH		5.19	0.74	7.00	4.0	5.2	5.46	4.76	
Temperature	°C	23.30	4.53	30.90	17.6	22.6	28.02	-	
Turbidity	NTU	23.12	30.61	108.00	2.3	14.0	24.2	-	
SW10 (SW9-03 and SW9-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.73	0.75	5.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	42.64	72.39	255.00	2.5	24.0	40	-	
Total Phosphorus as P	mg/l	1.21	0.79	2.46	0.3	0.7	2.09	-	
Total Nitrogen as N	mg/l	2.33	0.98	4.20	1.4	2.0	3.5	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.17	3.08	10.70	1.0	5.6	7.26	2.516	
Conductivity	µs/cm	140.80	46.13	214.00	67.0	139.0	183.6	105	
pH		4.86	0.59	5.70	4.0	4.7	5.44	4.36	
Temperature	°C	21.09	4.26	27.40	15.3	20.9	24.96	-	
Turbidity	NTU	47.07	87.43	274.00	3.6	10.7	46.68	-	

Section 9: Groundwater Monitoring – Water Quality Overview

Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. Prior to measurement, approximately three times the borehole volume of groundwater was purged from each bore. The results for each quarter are shown in the table below.

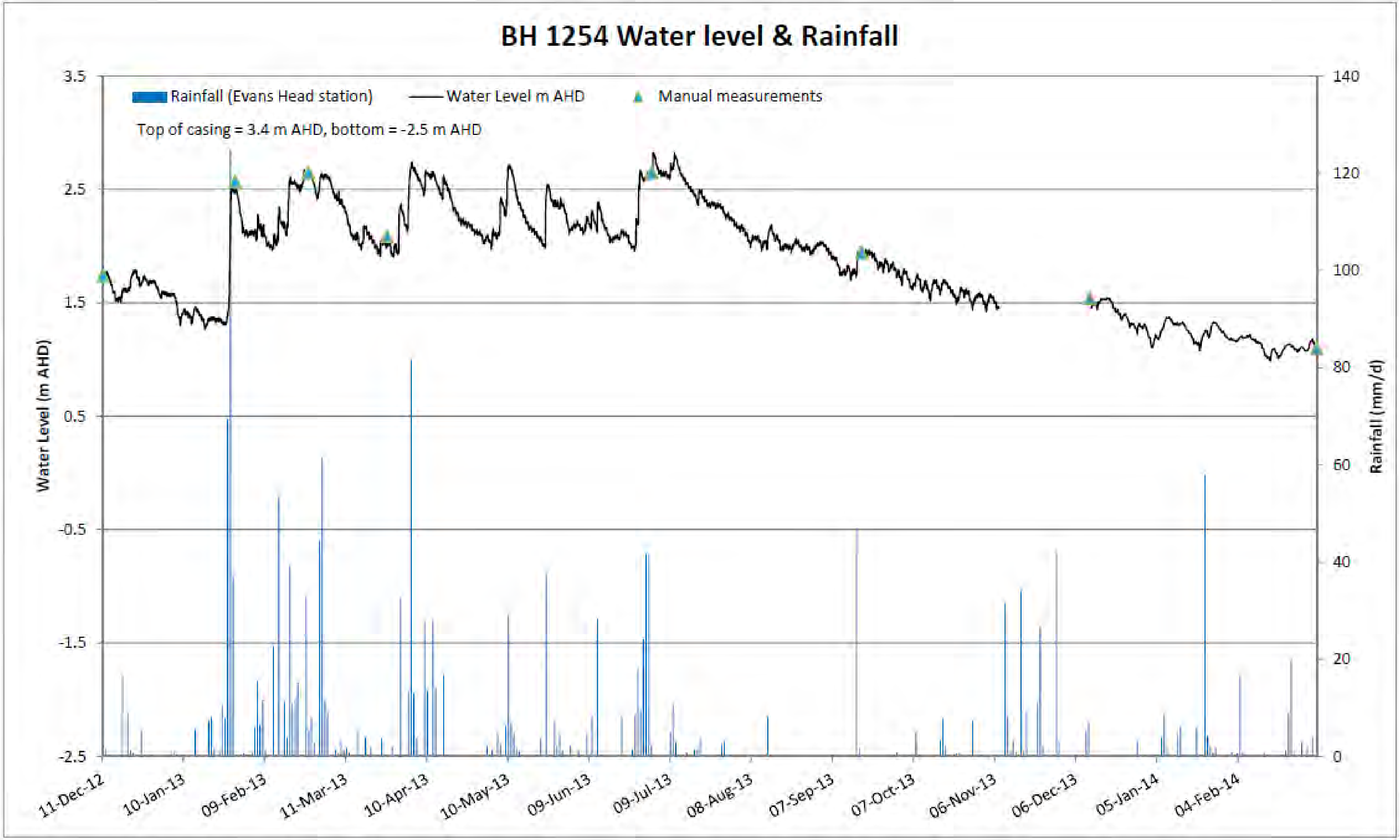
pH Statistics from Boreholes in Areas of Fill

Borehole Identifier	*Mean (Total)*	*Standard Deviation*	*Min*	*Max*	*Percentile*	
					P80	*P20*
BH1254	5.05	0.98	3.60	5.70	5.45	5.64
BH1255	5.98	1.69	4.10	8.20	5.80	6.82
BH1258	5.18	0.61	4.30	5.70	5.35	5.52
BH1259	5.75	0.37	5.30	6.10	5.80	6.04
BH1260	5.25	0.44	4.80	5.80	5.20	5.56
BH1261	6.33	0.25	6.00	6.60	6.35	6.48
BH1262	5.63	0.49	4.90	5.90	5.85	5.90
BH1263	5.80	0.41	5.40	6.20	5.80	6.14

Section 9: Groundwater Monitoring – Levels

Summary of Groundwater Level Monitoring – Section 9 DP2B Upgrade

Borehole Identifier	*Typical SWL (m below ground level)*		
	Average	*Median*	*Standard Deviation*
BH1255	-	-	-
BH1256	-	-	-
BH1257	-	-	-
BH1258	0.88	0.81	0.42
BH1259	0.51	0.58	0.27
BH1260	-	-	-
BH1261	0.36	0.49	0.40
BH1262	2.83	2.93	0.27
BH1263	0.88	0.8	0.42
BH1264	-	-	-
BH1265	-	-	-
BH1266	-	-	-
BH1267	-	-	-
BH1268	-	-	-
BH1269	-	-	-


BH 1254 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.4 m AHD, bottom = -2.5 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
140
120
100
80
60
40
20
0
11-Dec-12
10-Jan-13
09-Feb-13
11-Mar-13
10-Apr-13
10-May-13
09-Jun-13
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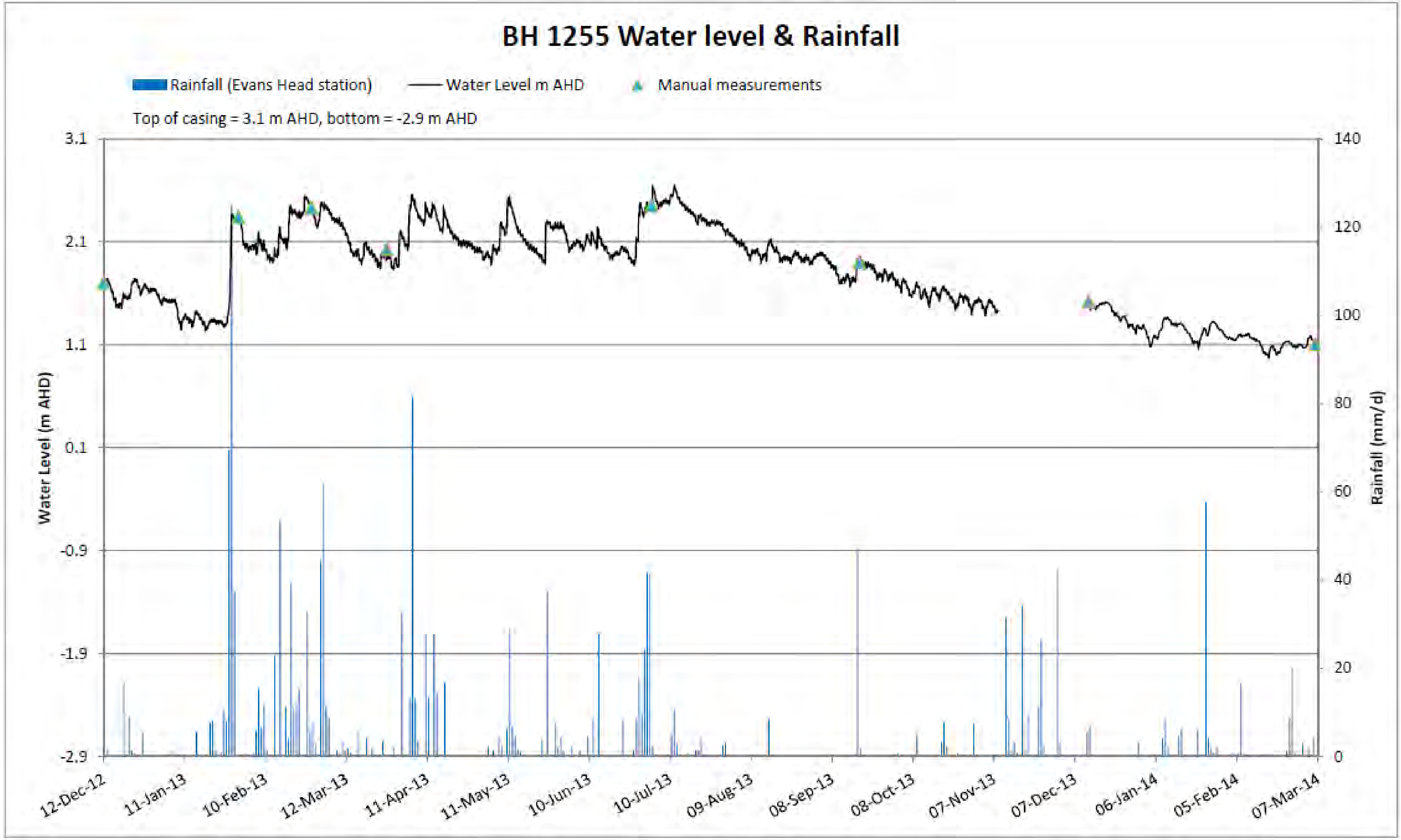
05-Jan-14
04-Feb-14



BH 1255 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.1 m AHD, bottom = -2.9 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.1
2.1
1.1
0.1
-0.9
-1.9
-2.9
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
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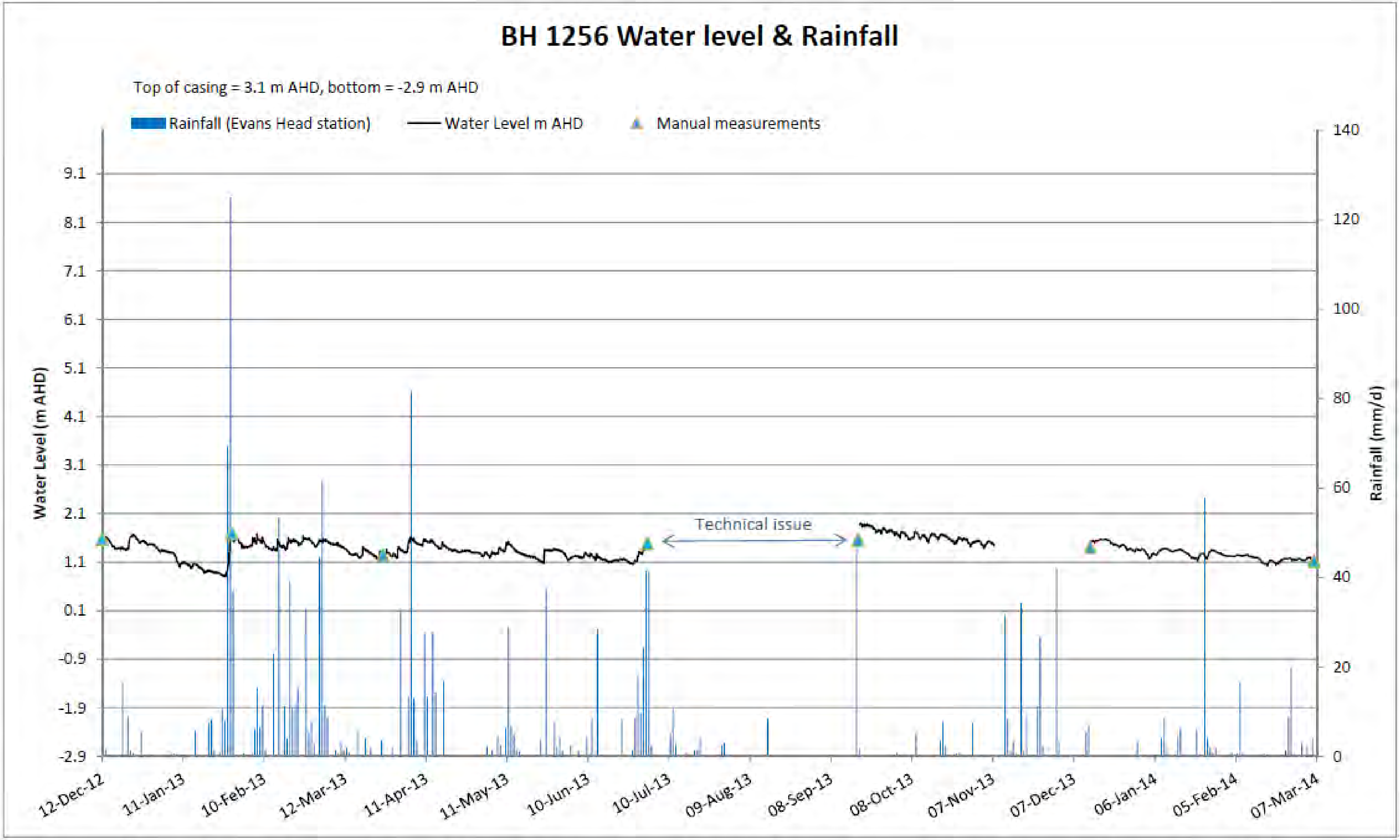
06-Jan-14
05-Feb-14
07-Mar-14


BH 1256 Water level & Rainfall
Top of casing = 3.1 m AHD, bottom = -2.9 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Technical issue
Water Level (m AHD)
Rainfall (mm/d)
9.1
8.1
7.1
6.1
5.1
4.1
3.1
2.1
1.1
0.1
-0.9
-1.9
-2.9
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
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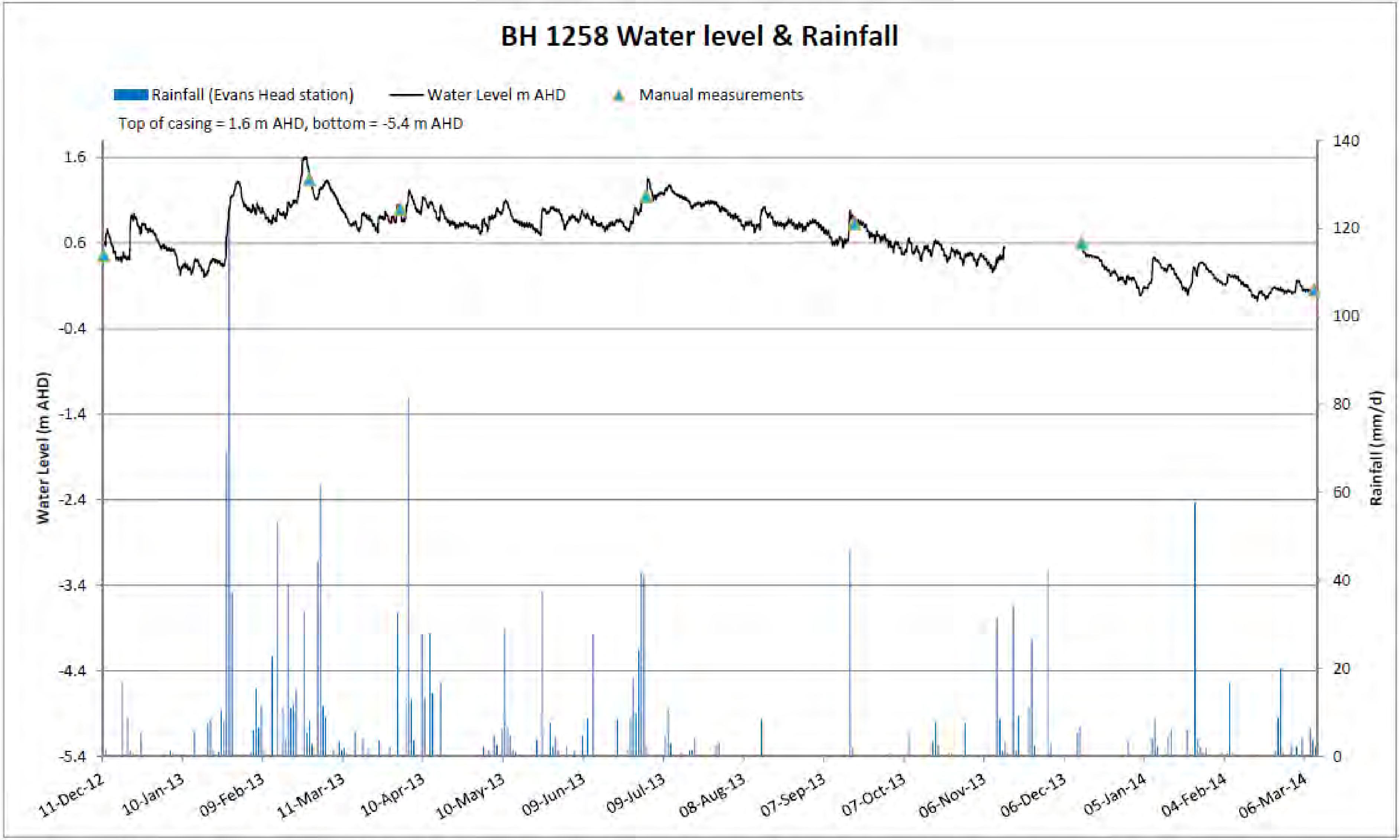
06-Jan-14
05-Feb-14
07-Mar-14



BH 1258 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.6 m AHD, bottom = -5.4 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
140
120
100
80
60
40
20
0
11-Dec-12
10-Jan-13
09-Feb-13
11-Mar-13
10-Apr-13
10-May-13
09-Jun-13
09-Jul-13
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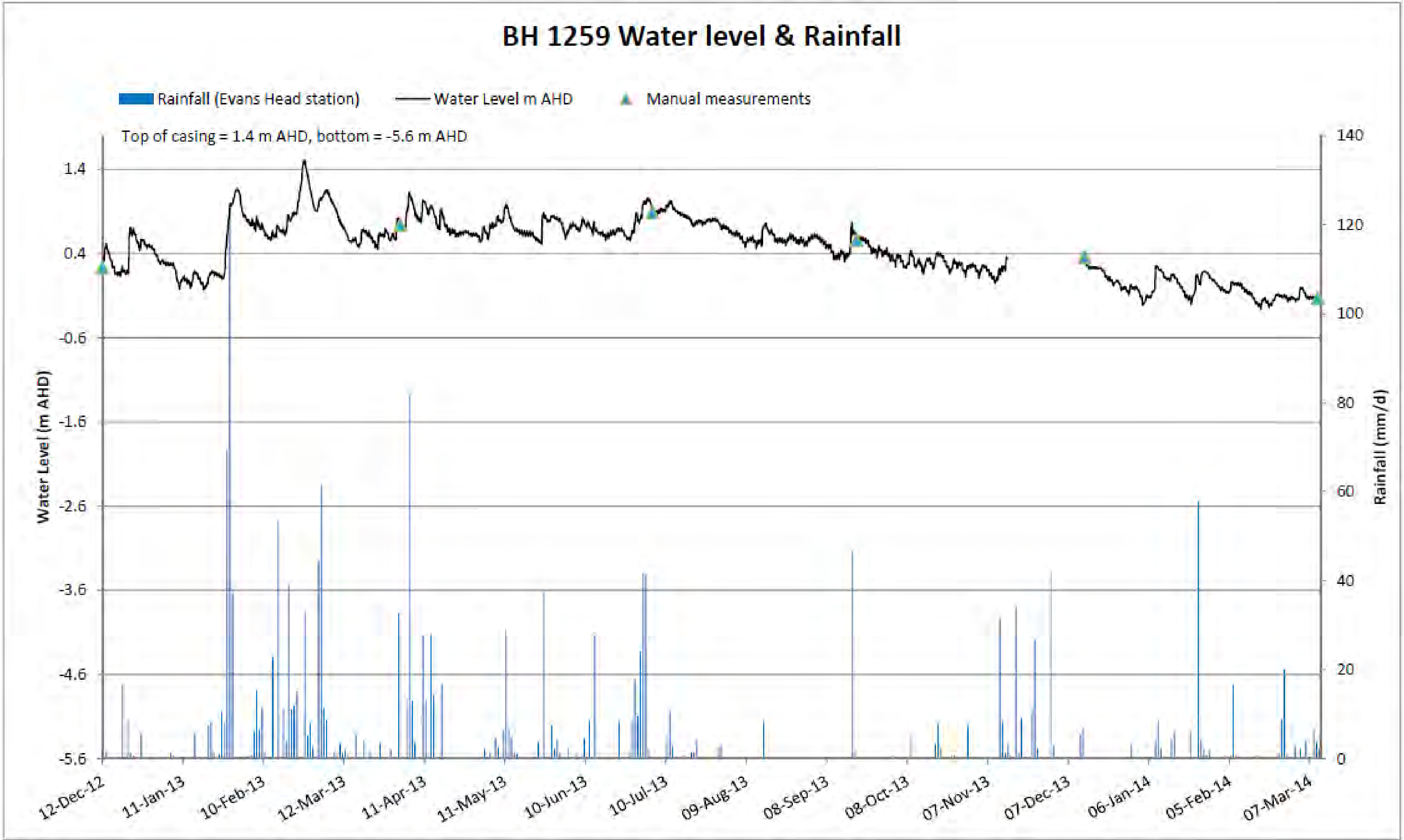
04-Feb-14
06-Mar-14


BH 1259 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.4 m AHD, bottom = -5.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.4
0.4
-0.6
-1.6
-2.6
-3.6
-4.6
-5.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
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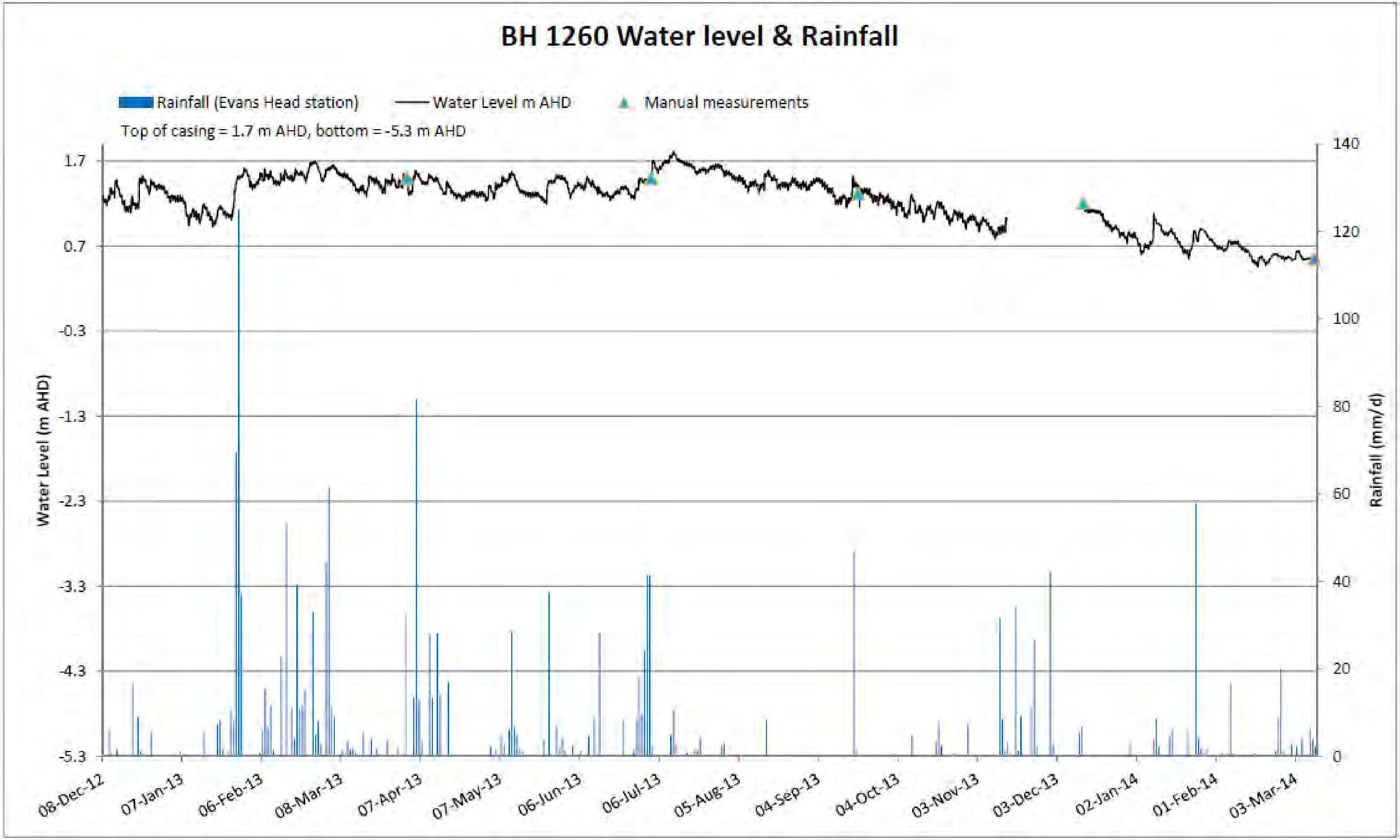
06-Jan-14
05-Feb-14
07-Mar-14


BH 1260 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.7 m AHD, bottom = -5.3 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.7
0.7
-0.3
-1.3
-2.3
-3.3
-4.3
-5.3
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
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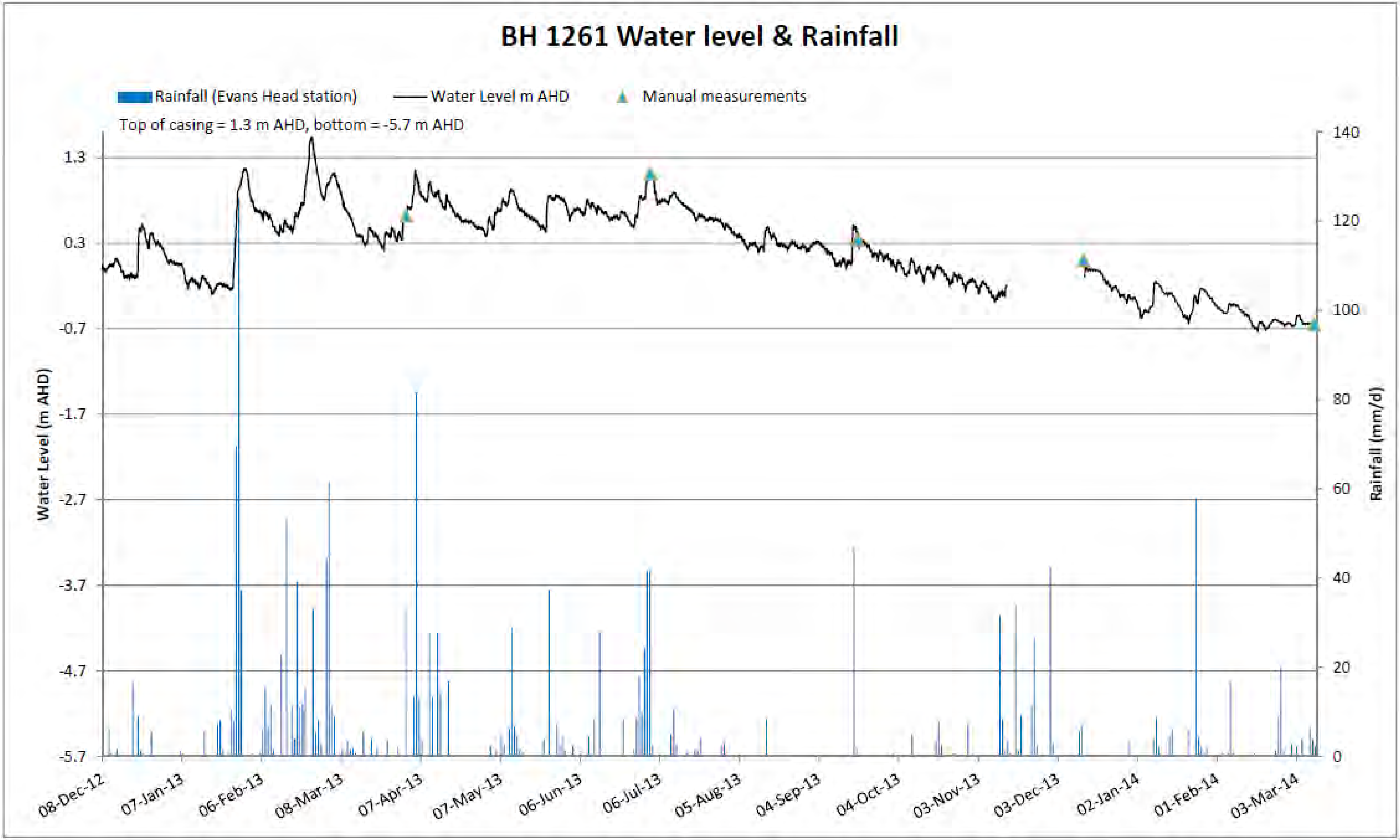
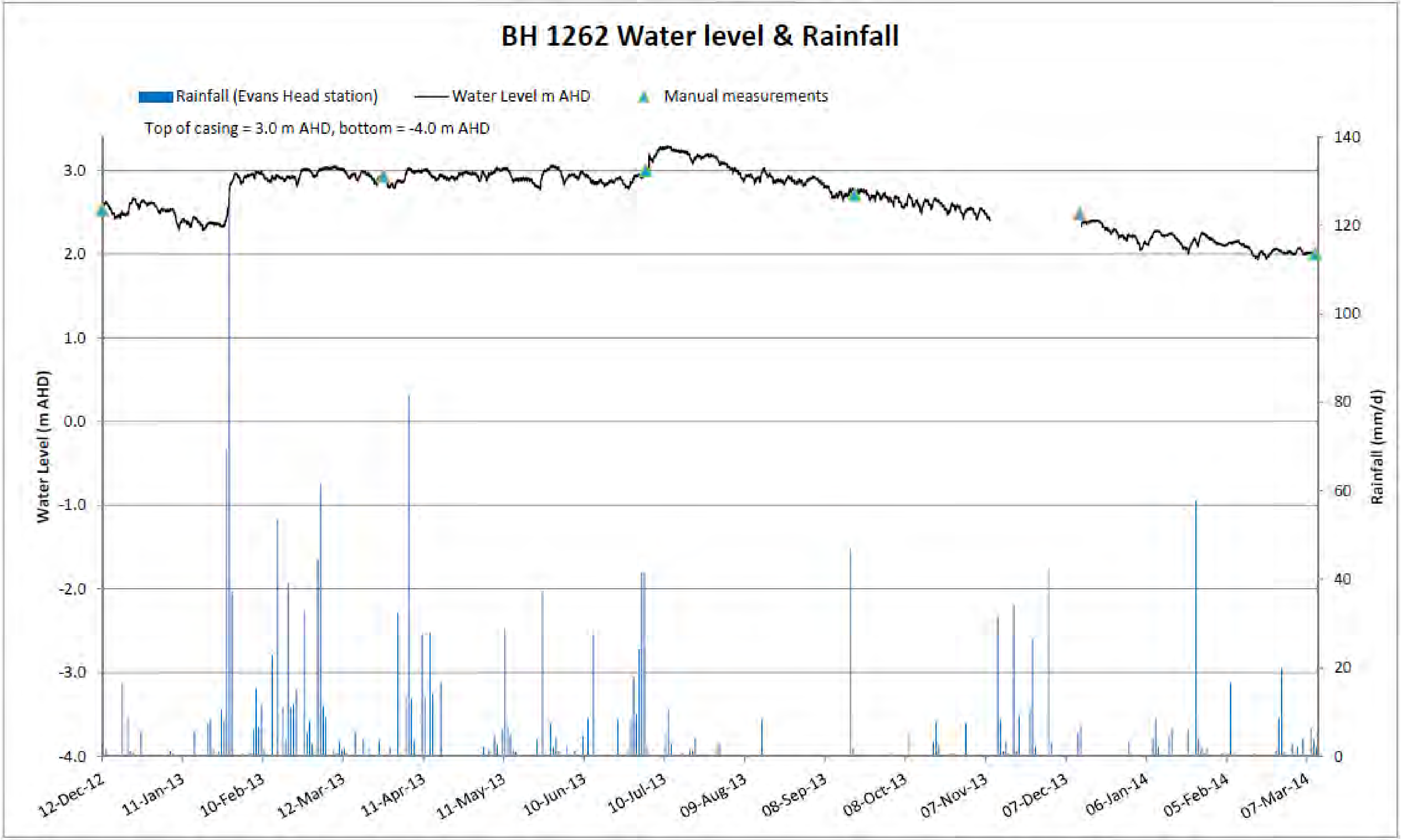
02-Jan-14
01-Feb-14
03-Mar-14


BH 1261 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.3 m AHD, bottom = -5.7 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.3
0.3
-0.7
-1.7
-2.7
-3.7
-4.7
-5.7
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1262 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.0 m AHD, bottom = -4.0 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
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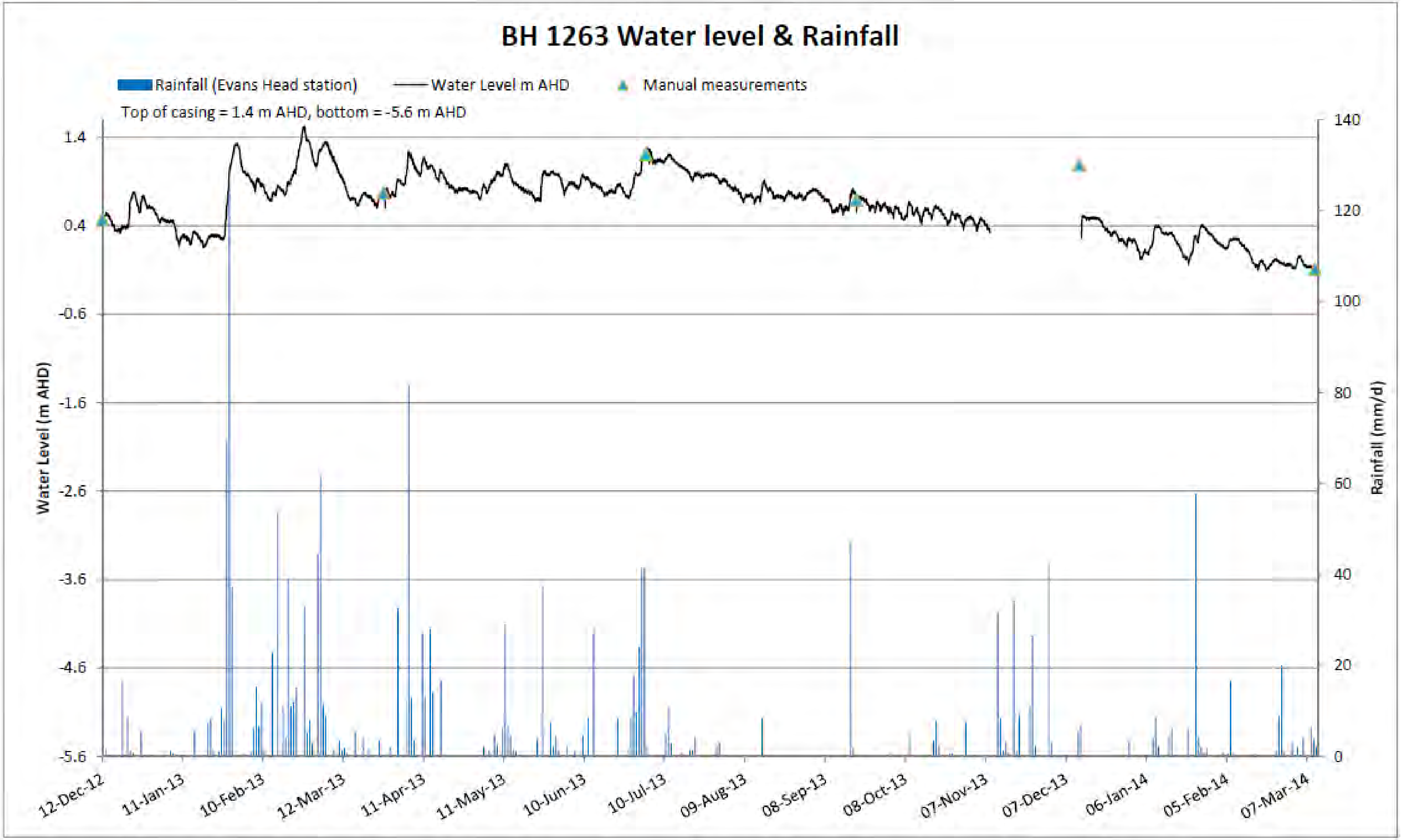
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14


BH 1263 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.4 m AHD, bottom = -5.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.4
0.4
-0.6
-1.6
-2.6
-3.6
-4.6
-5.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
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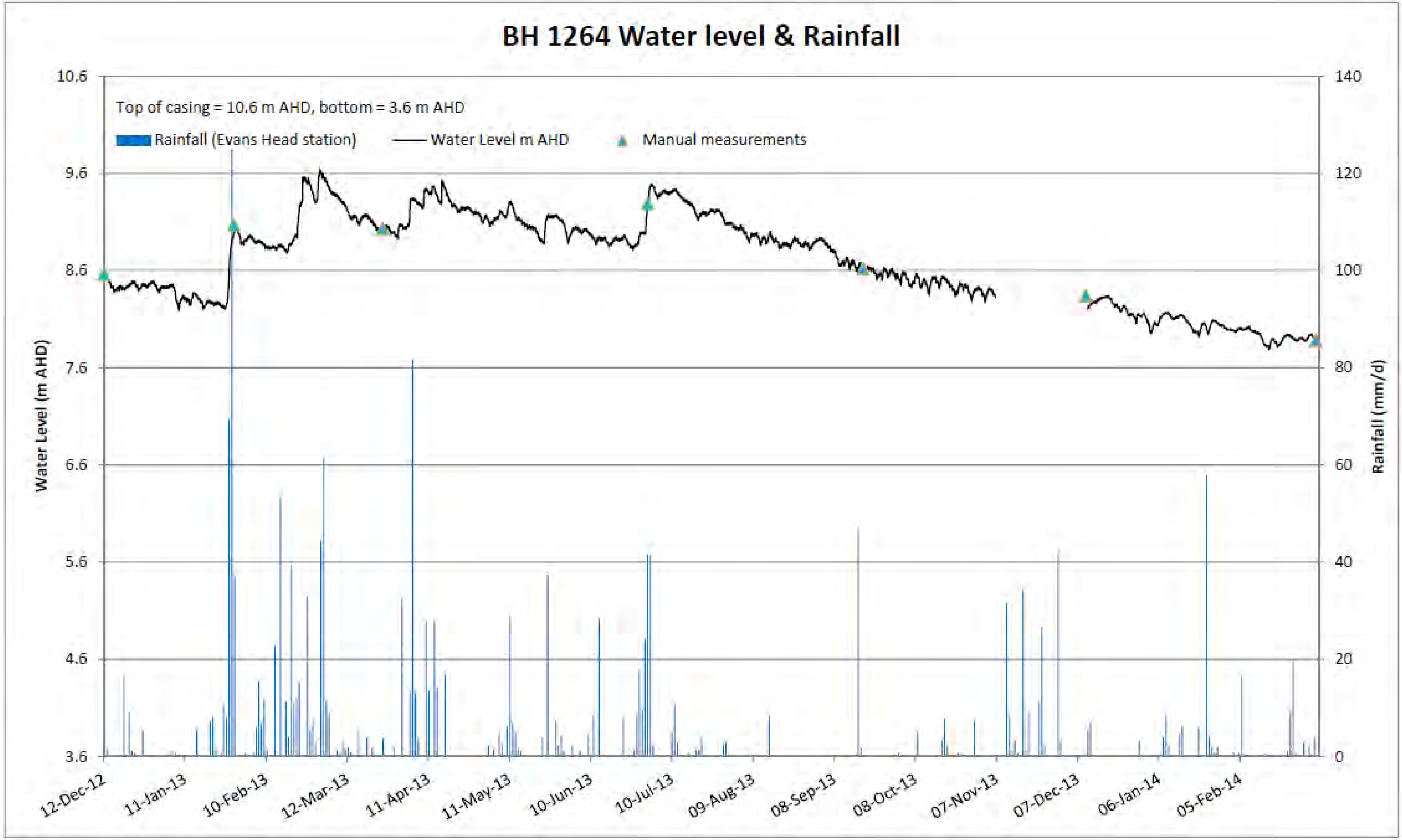
06-Jan-14
05-Feb-14
07-Mar-14


BH 1264 Water level & Rainfall
Top of casing = 10.6 m AHD, bottom = 3.6 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
10.6
9.6
8.6
7.6
6.6
5.6
4.6
3.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
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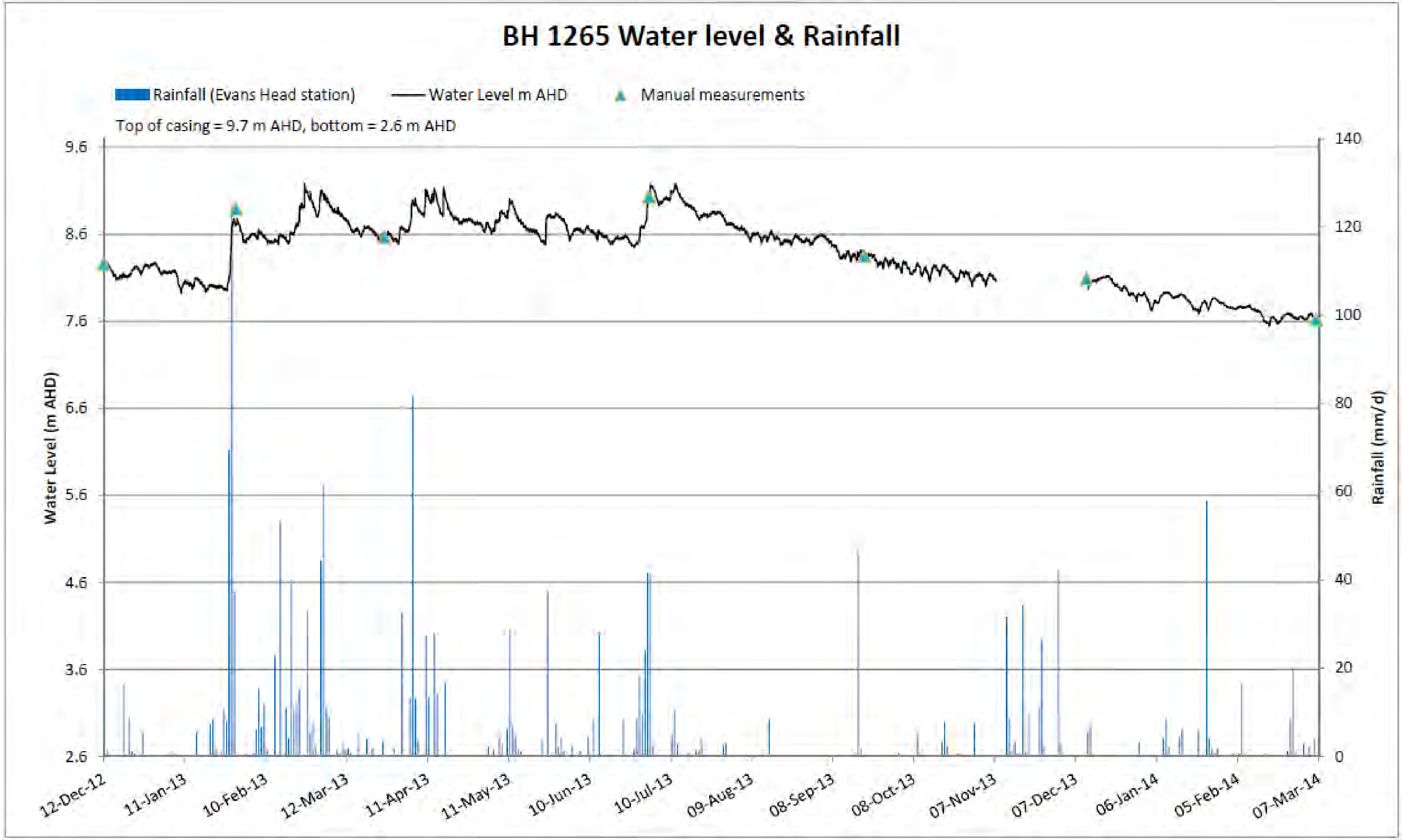
06-Jan-14
05-Feb-14


BH 1265 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 9.7 m AHD, bottom = 2.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
9.6
8.6
7.6
6.6
5.6
4.6
3.6
2.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
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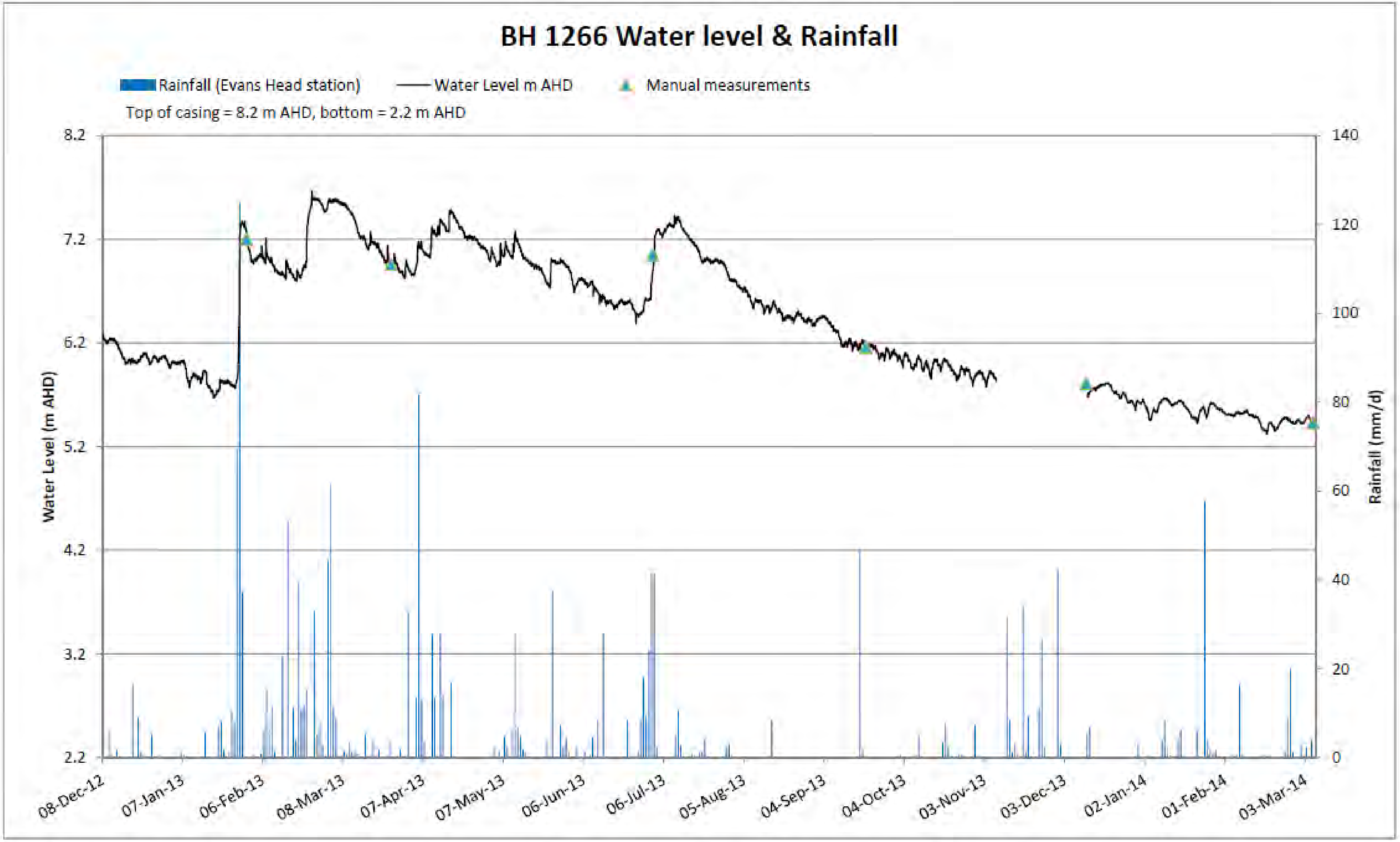
05-Feb-14
07-Mar-14


BH 1266 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 8.2 m AHD, bottom = 2.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
8.2
7.2
6.2
5.2
4.2
3.2
2.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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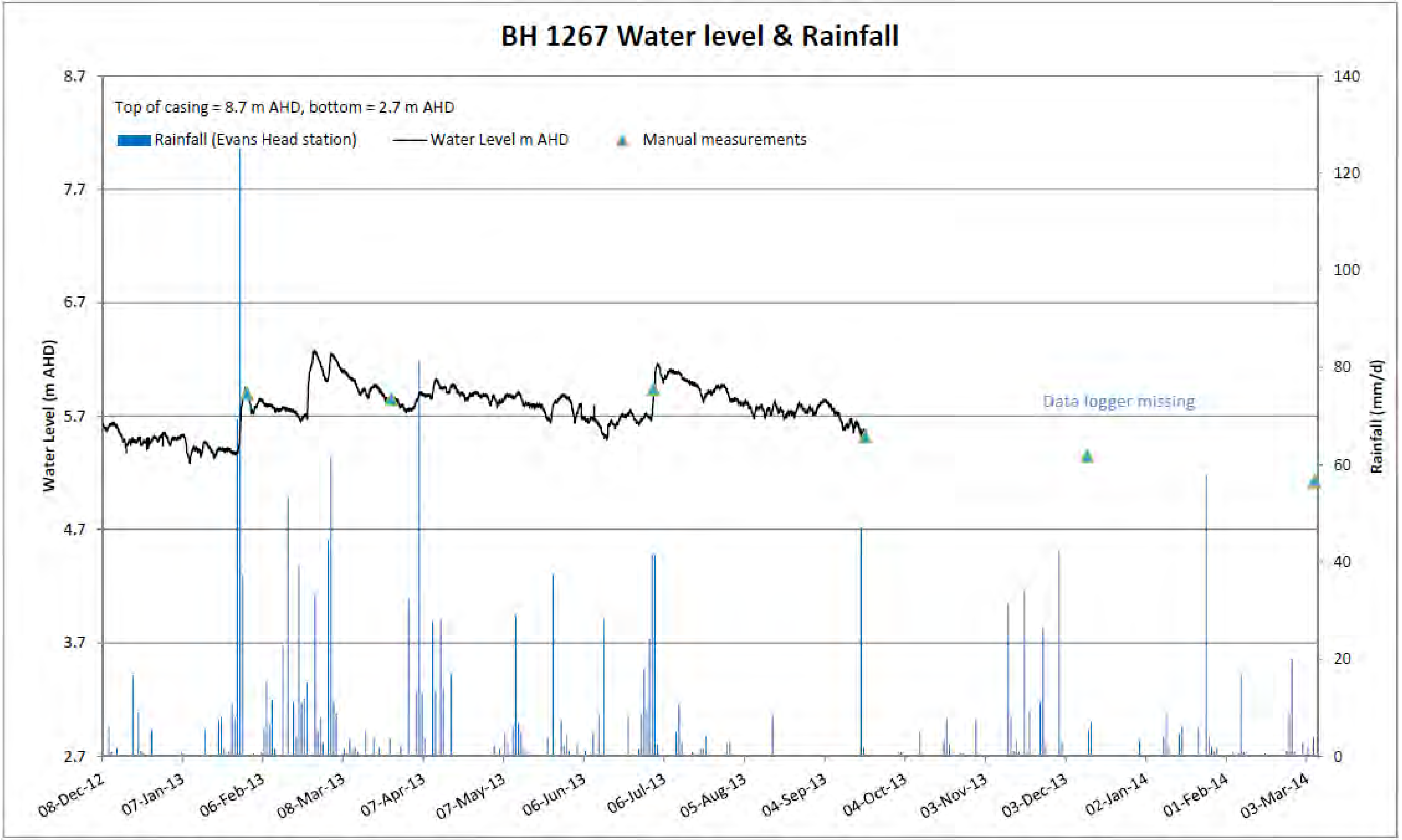
01-Feb-14
03-Mar-14



BH 1267 Water level & Rainfall
Top of casing = 8.7 m AHD, bottom = 2.7 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Data logger missing
Water Level (m AHD)
Rainfall (mm/d)
8.7
7.7
6.7
5.7
4.7
3.7
2.7
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

Appendix I

Section 10 - Richmond River to Coolgardie Road: Pre-Construction Monitoring Results

Section 10: Surface Water Monitoring Locations and associated Sensitive Receiving Environments

Surface Water Sample Locations / Waterway	*Sensitive aquatic receiving environments and groundwater dependent ecosystems (GDE's)*
SW11 - Richmond River	▪ No significant sensitive receiving environment
SW12 - Unnamed tributary Bingal Creek, CH 149 250 m	▪ No significant sensitive receiving environment
SW13 - Saltwater Creek	▪ GDE
SW14 - Randal's Creek	▪ No significant sensitive receiving environment

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 10: Surface Water Monitoring – Overview of Results

Physical properties

Temperature generally exhibited a gradual increase generally from the high-teens (15-18°C) in winter up to the high-20s (25-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. pH levels fell within the range of 4.1 to 9.2.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of <0.01 to 2.02 mg/L. Total Nitrogen values were found to be in the range of <0.1to 2.6 mg/L.

Heavy metals

Heavy metals were not sampled for most points within section 10.

Summary of Visual Observations and Sampling Results

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
GDE07 Unnamed Swamp Ch. 148,900	▪ No record of visual observations provided.	▪ O&G: <5mg/L ▪ SS: <5-275mg/L ▪ TP: <0.01-0.63mg/L ▪ TN: 0.5-2.9mg/L ▪ DO: 1.6-8.1mg/L ▪ EC: 95-275µS/cm ▪ pH: 4.8-8.3 ▪ Temp: 15.6-29.0ºC ▪ NTU: 3.7-259
SW11 Richmond River Ch. 145,900	▪ As above.	▪ O&G: <5mg/L ▪ SS: 28-158mg/L ▪ TP: 0.02-0.38mg/L ▪ TN: <0.1-0.9mg/L ▪ DO: 1.7-9.9mg/L ▪ EC: 122-19,300µS/cm ▪ pH: 5.7-7.9 ▪ Temp: 16.3-29ºC ▪ NTU: 4.9-111
SW12 Unnamed tributary of Bingal Creek Ch. 149,300	▪ As above.	▪ O&G: <5mg/L ▪ SS: 16-158mg/L ▪ TP: 0.02-0.38mg/L ▪ TN: <0.1-0.9mg/L ▪ DO: 1.7-9.9mg/L ▪ EC: 122-19,800µS/cm ▪ pH: 5.7-7.9 ▪ Temp: 16.3-29.0ºC ▪ NTU: 4.9-111
SW13/GDE08 Saltwater Creek Ch. 157,200	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-218mg/L ▪ TP: 0.02-2.02mg/L ▪ TN: 0.3-2.6mg/L ▪ DO: 0.8-16.4mg/L ▪ EC: 120-597µS/cm ▪ pH: 4.1-9.2 ▪ Temp: 18.3-30.5ºC ▪ NTU: 4.3-77.0
SW14 Randal's Creek Ch. 157,800	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-217mg/L ▪ TP: <0.01-0.19mg/L ▪ TN: <0.1-1.2mg/L ▪ DO: 0.2-8.7mg/L ▪ EC: 94-197µS/cm ▪ pH: 4.3-7.0 ▪ Temp: 15.3-24.7ºC ▪ NTU: 8.4-49.0

Note: * Ch. = Highway Chainage

Section 10: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 10							
SW11 (SW10-01 and SW10-02)									
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	62.92	51.75	158.00	16.0	35.0	116.2	-	
Total Phosphorus as P	mg/l	0.17	0.11	0.38	0.0	0.2	0.294	-	
Total Nitrogen as N	mg/l	0.54	0.30	0.90	0.1	0.6	0.8	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.58	2.26	9.90	1.7	8.0	9.08	6.818	
Conductivity	µs/cm	2006.83	3002.41	10800.00	132.0	922.0	2985.6	182.6	
pH		6.82	0.62	7.90	5.7	6.9	7.182	6.54	
Temperature	°C	22.48	3.86	29.00	16.3	23.3	25.1	-	
Turbidity	NTU	62.99	40.47	130.00	8.2	52.1	107	-	
GDE07									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	37.50	73.03	275.00	2.5	14.0	35.4	-	
Total Phosphorus as P	mg/l	0.12	0.17	0.63	0.0	0.1	0.12	-	
Total Nitrogen as N	mg/l	0.92	0.67	2.90	0.5	0.7	1.12	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.74	2.37	9.00	1.6	6.7	7.18	3.19	
Conductivity	µs/cm	263.25	214.24	648.00	67.0	174.0	509.6	84	
pH		6.43	1.06	8.30	4.8	6.5	7.24	5.36	
Temperature	°C	43.17	71.37	258.00	15.6	22.3	25.7	-	
Turbidity	NTU	45.15	83.17	295.00	8.6	19.9	30.9	-	
SW12 (SW10-03 and SW10-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	129.08	102.17	334.00	33.0	92.0	218.8	-	
Total Phosphorus as P	mg/l	0.20	0.13	0.41	0.0	0.2	0.306	-	
Total Nitrogen as N	mg/l	1.32	1.02	3.60	0.2	0.9	2	-	
Dissolved Oxygen	mg/l	8.58	1.56	10.20	4.5	8.9	9.56	8	
Conductivity	µs/cm	161.02	97.09	383.00	38.0	146.0	217	74.56	
pH		6.90	1.02	8.50	5.1	7.2	7.56	5.944	
Temperature	°C	24.80	5.47	32.70	16.2	24.4	29.3	-	
Turbidity	NTU	358.55	231.43	697.00	63.0	292.0	668	-	
SW13 (SW10-05 and SW10-06)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.77	0.97	6.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	32.58	58.03	218.00	2.5	15.0	34	-	
Total Phosphorus as P	mg/l	0.23	0.54	2.02	0.0	0.1	0.148	-	
Total Nitrogen as N	mg/l	0.72	0.63	2.60	0.3	0.5	0.78	-	

	Units	SECTION 10							
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.40	3.82	16.40	0.8	7.5	8.56	4.656	
Conductivity	µs/cm	141.67	37.98	187.00	82.0	149.0	176	102.8	
pH		6.28	1.20	9.20	4.1	6.1	6.66	5.9	
Temperature	°C	24.62	4.06	30.50	18.3	22.8	29.06	-	
Turbidity	NTU	27.03	11.69	50.90	11.1	23.2	33	-	
SW14 (SW10-07 and SW10-08)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	39.42	63.37	217.00	2.5	13.0	32.4	-	
Total Phosphorus as P	mg/l	0.06	0.05	0.19	0.0	0.0	0.08	-	
Total Nitrogen as N	mg/l	0.44	0.33	1.20	0.1	0.4	0.46	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.12	2.55	8.70	0.2	6.6	7.68	5.6	
Conductivity	µs/cm	103.88	46.03	154.00	1.6	108.5	142.8	77.4	
pH		5.80	0.83	7.00	4.3	5.8	6.5	5.21	
Temperature	°C	20.77	3.18	24.70	15.3	21.0	23.54	-	
Turbidity	NTU	21.45	10.38	51.40	13.7	19.2	22.7	-	

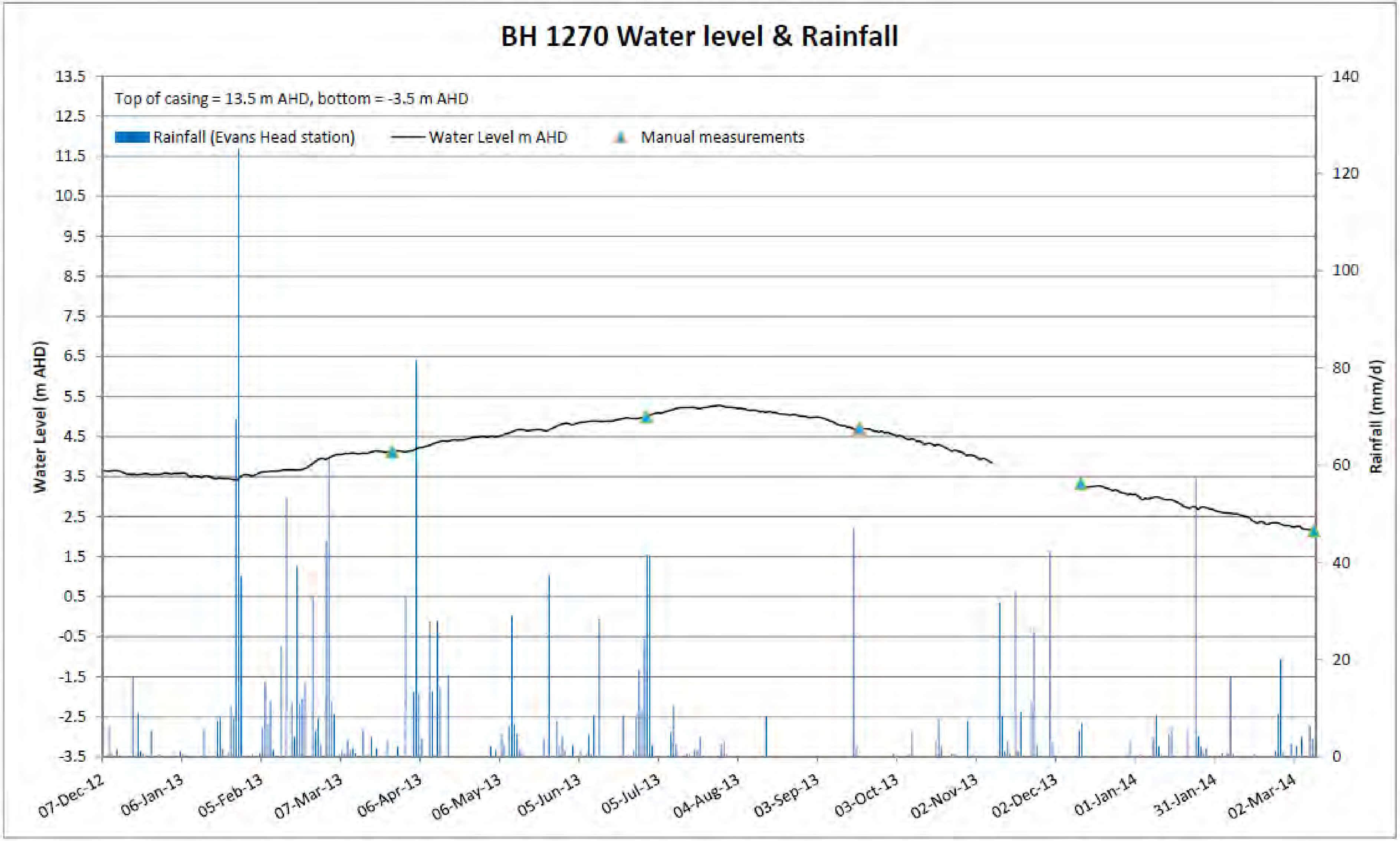
Section 10: Groundwater Monitoring – Water Quality Overview

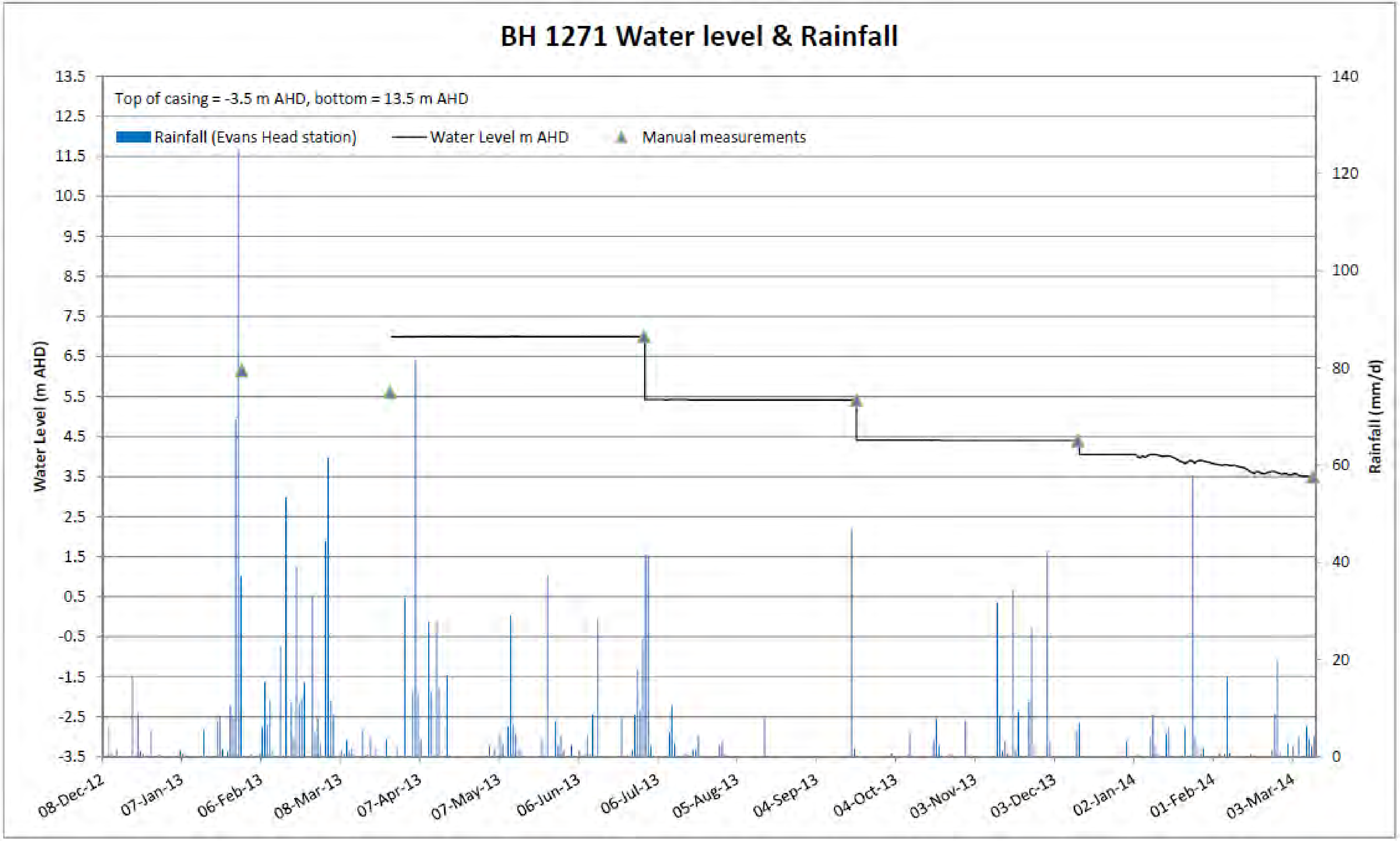
Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. No boreholes were measured in Section 10.

Section 10: Groundwater Monitoring – Levels

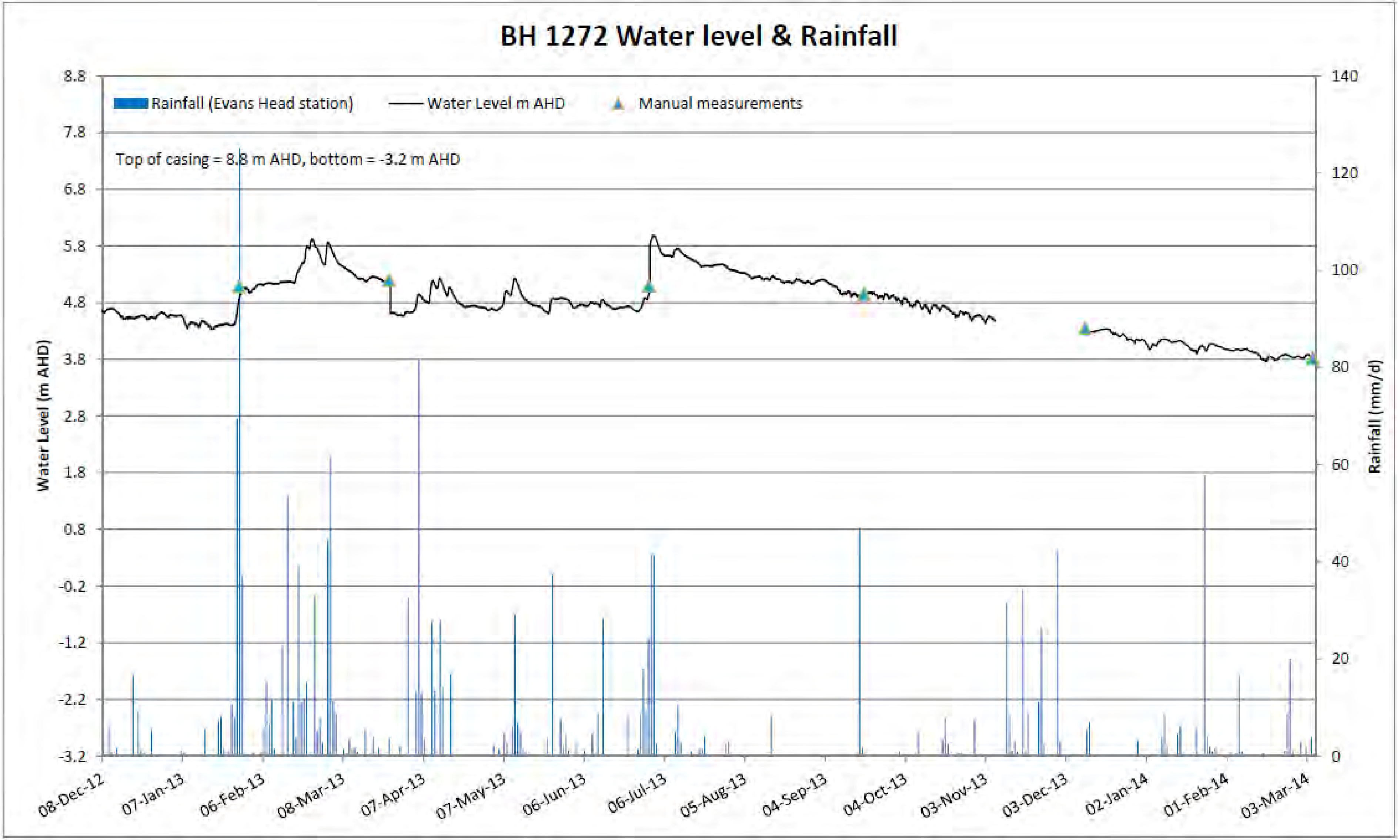
Summary of Groundwater Level Monitoring – Section 10 DP2B Upgrade

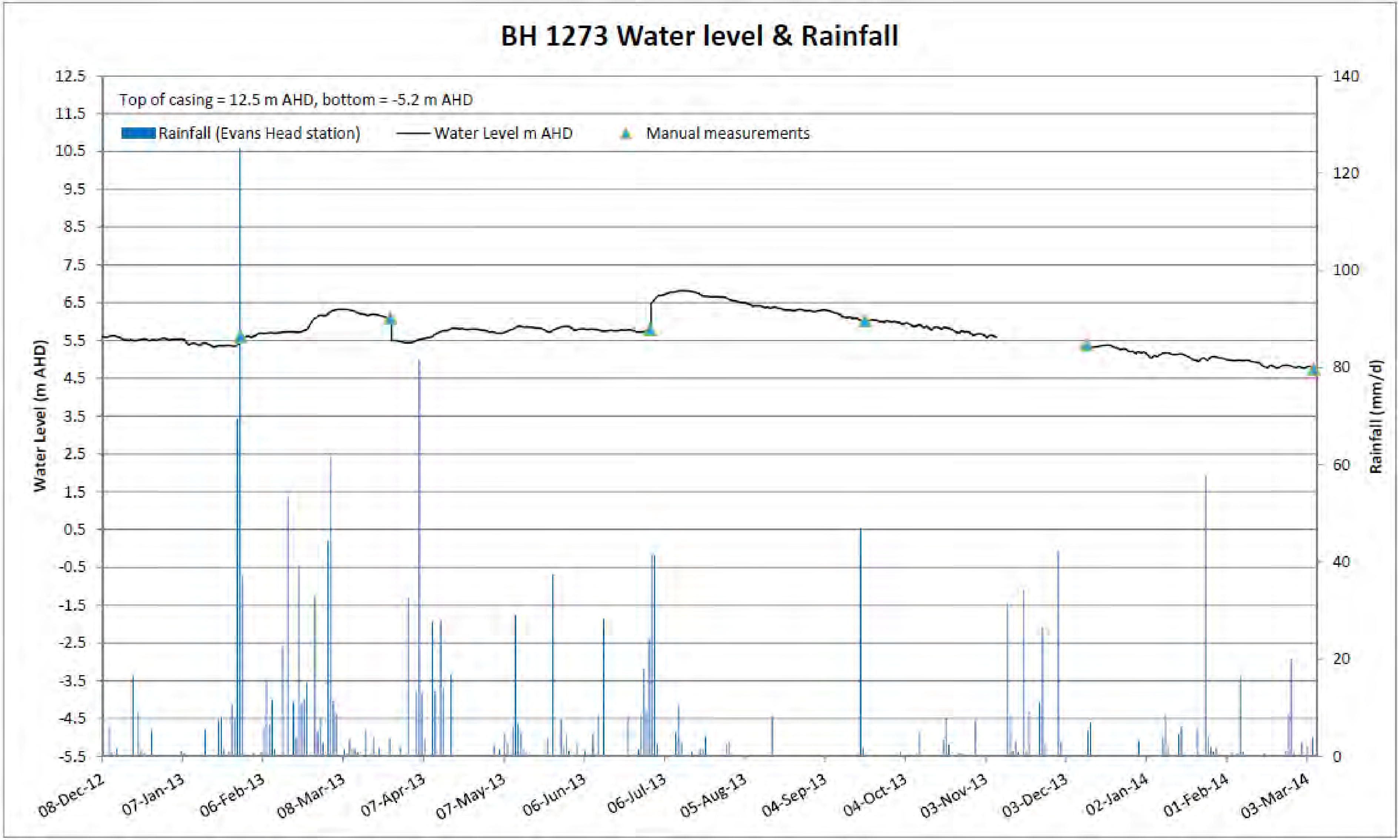
Borehole Identifier	***Typical SWL (m below ground level)***		
	Average	***Median***	***Standard Deviation***
BH1271	-	-	-
BH1272	-	-	-
BH1273	-	-	-
BH1274	-	-	-
BH1275	-	-	-
BH1276	-	-	-
BH1277	-	-	-
BH1278	-	-	-
BH1279	-	-	-
BH1280	-	-	-
BH1281	-	-	-
BH1282	-	-	-


BH 1270 Water level & Rainfall
Top of casing = 13.5 m AHD, bottom = -3.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
13.5
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
140
120
100
80
60
40
20
0
07-Dec-12
06-Jan-13
05-Feb-13
07-Mar-13
06-Apr-13
06-May-13
05-Jun-13
05-Jul-13
04-Aug-13
03-Sep-13
03-Oct-13
02-Nov-13
02-Dec-13
01-Jan-14
31-Jan-14
02-Mar-14



BH 1271 Water level & Rainfall
Top of casing = -3.5 m AHD, bottom = 13.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
13.5
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1272 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 8.8 m AHD, bottom = -3.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
8.8
7.8
6.8
5.8
4.8
3.8
2.8
1.8
0.8
-0.2
-1.2
-2.2
-3.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1273 Water level & Rainfall
Top of casing = 12.5 m AHD, bottom = -5.2 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
-4.5
-5.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
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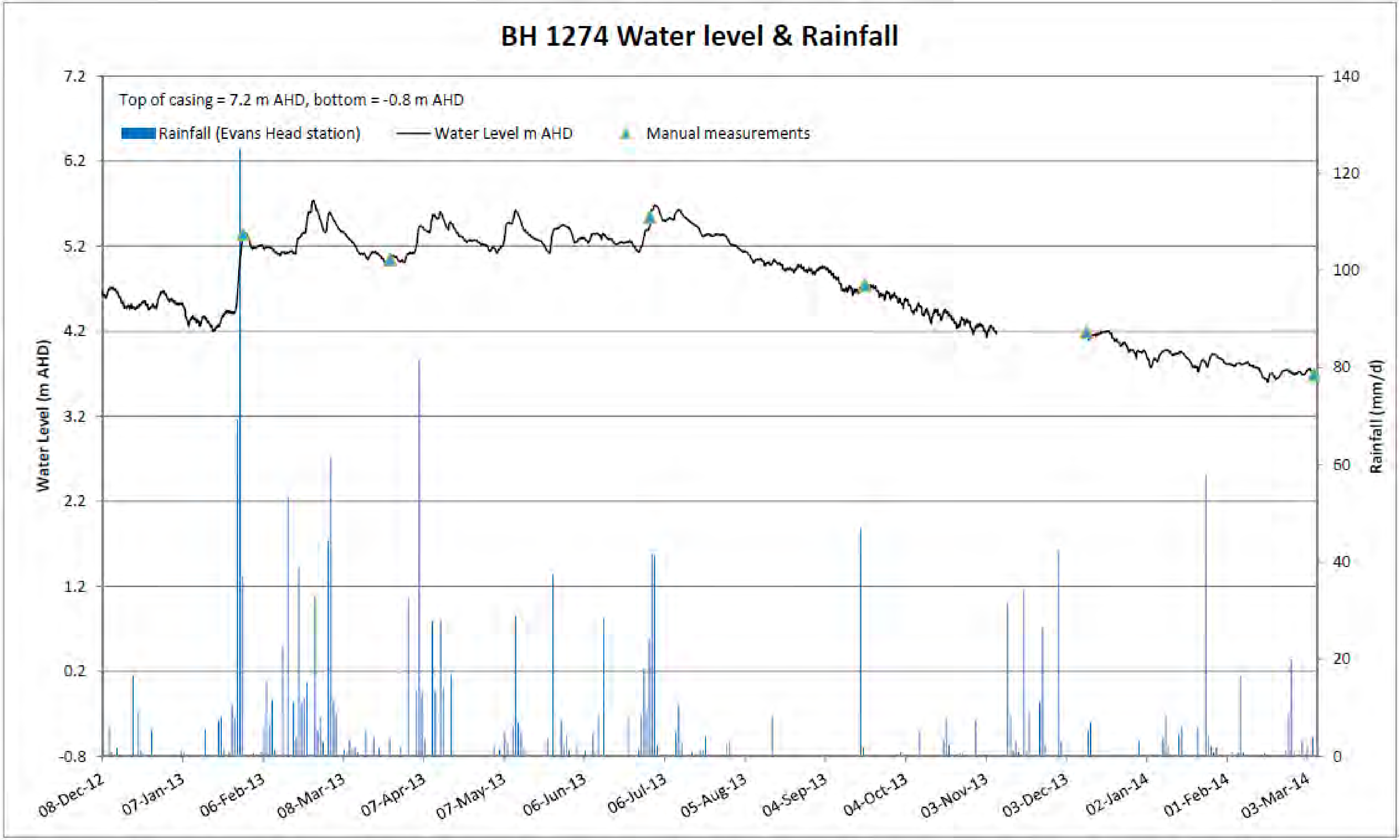
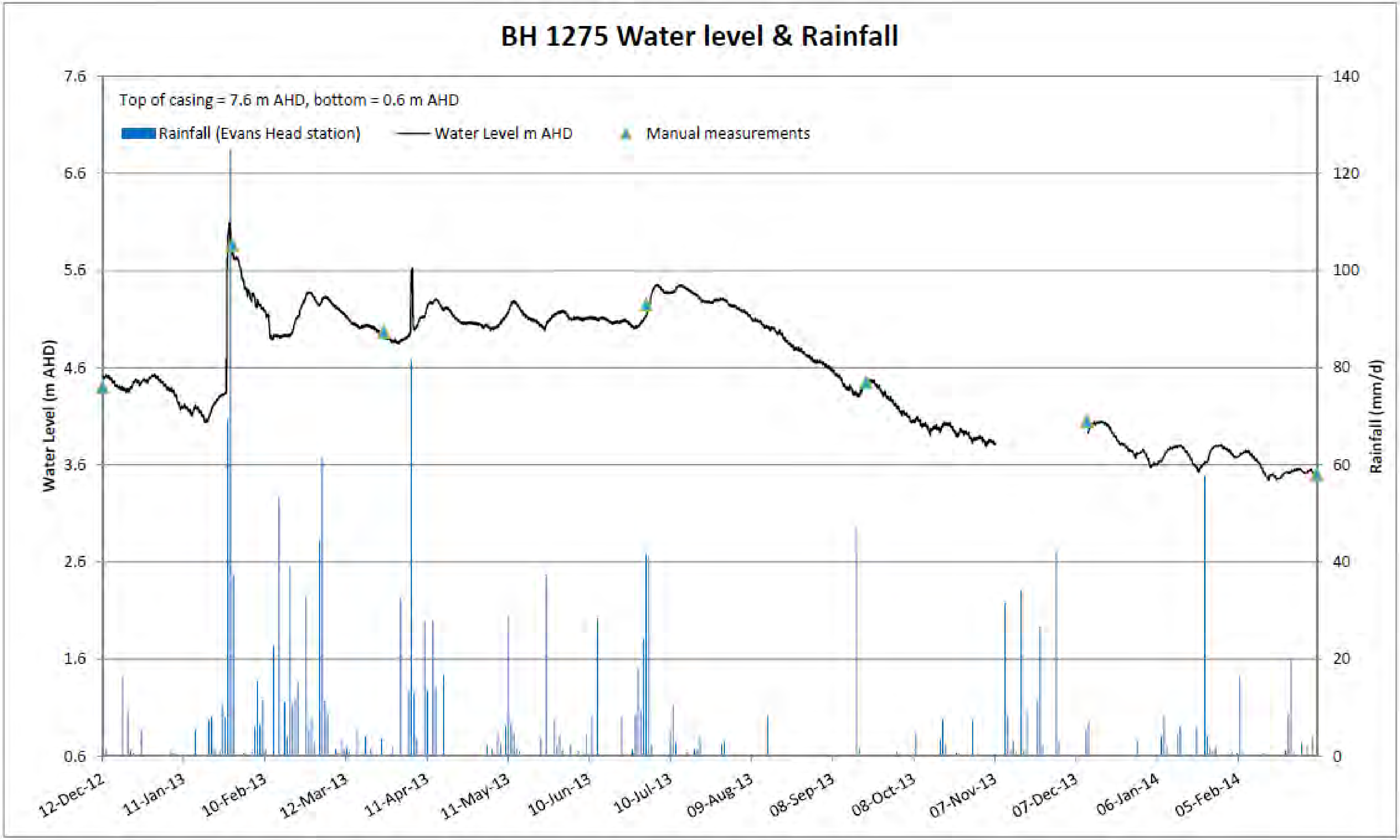
01-Feb-14
03-Mar-14


BH 1274 Water level & Rainfall
Top of casing = 7.2 m AHD, bottom = -0.8 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
7.2
6.2
5.2
4.2
3.2
2.2
1.2
0.2
-0.8
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1275 Water level & Rainfall
Top of casing = 7.6 m AHD, bottom = 0.6 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
7.6
6.6
5.6
4.6
3.6
2.6
1.6
0.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
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08-Sep-13
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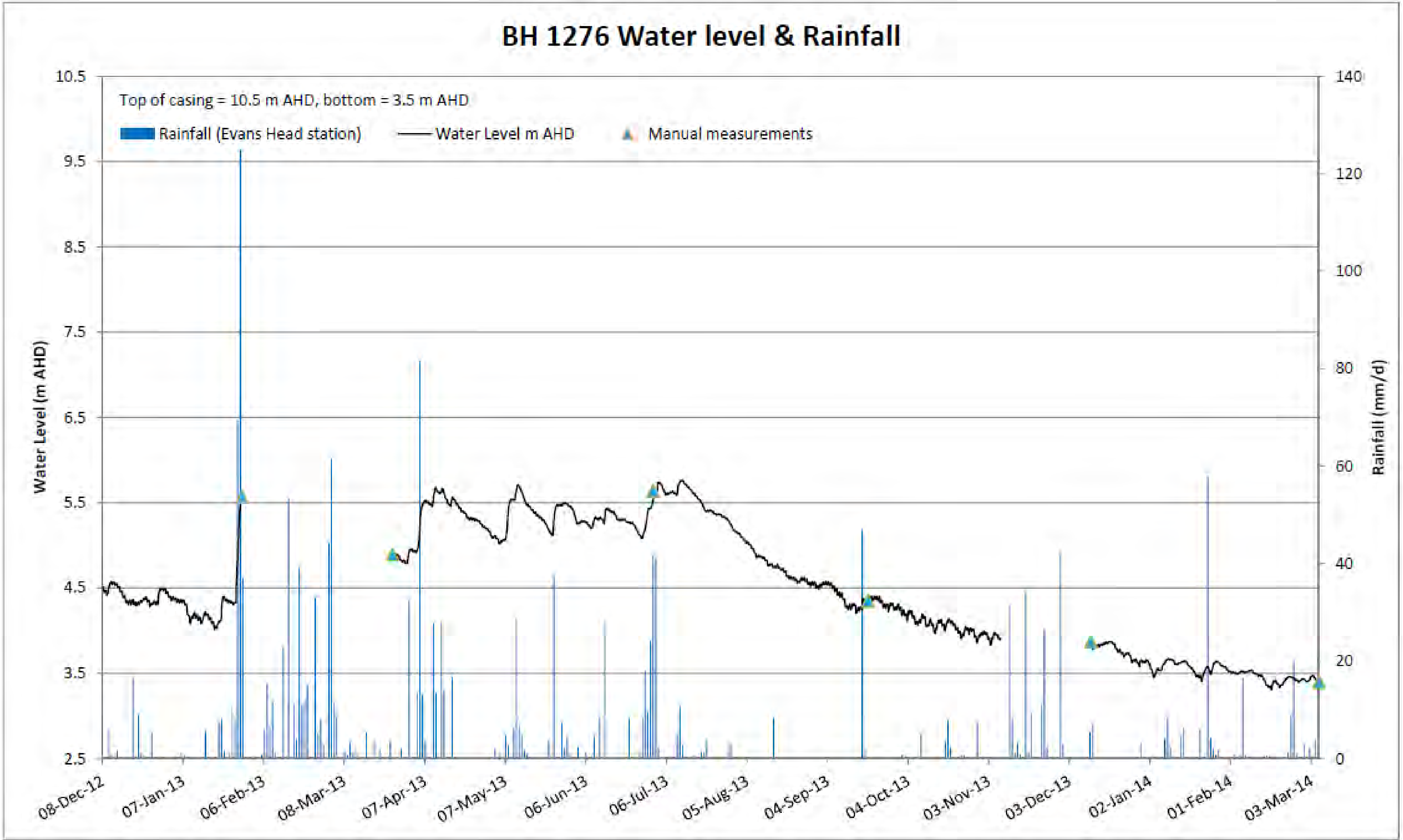
07-Dec-13
06-Jan-14
05-Feb-14


BH 1276 Water level & Rainfall
Top of casing = 10.5 m AHD, bottom = 3.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
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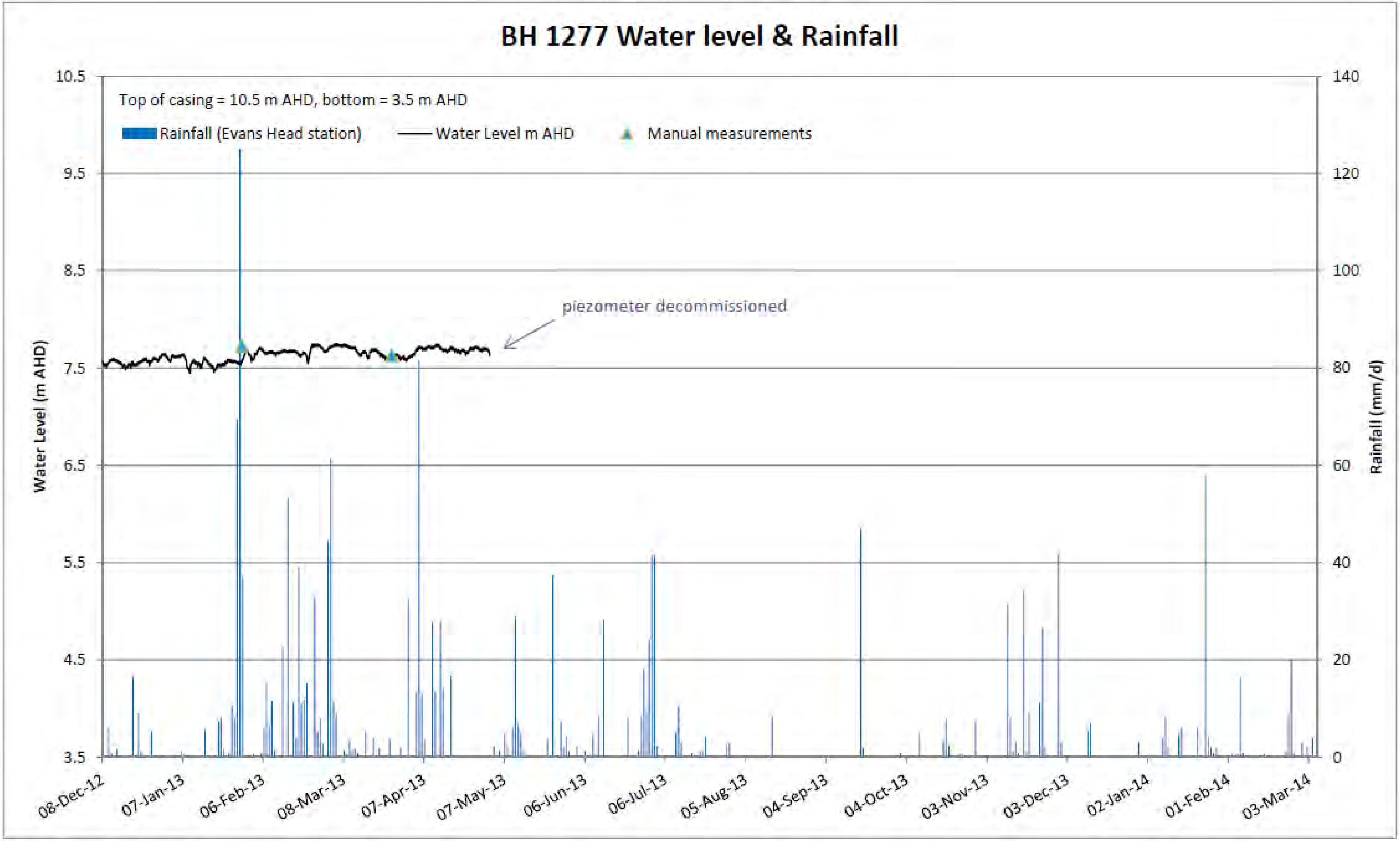
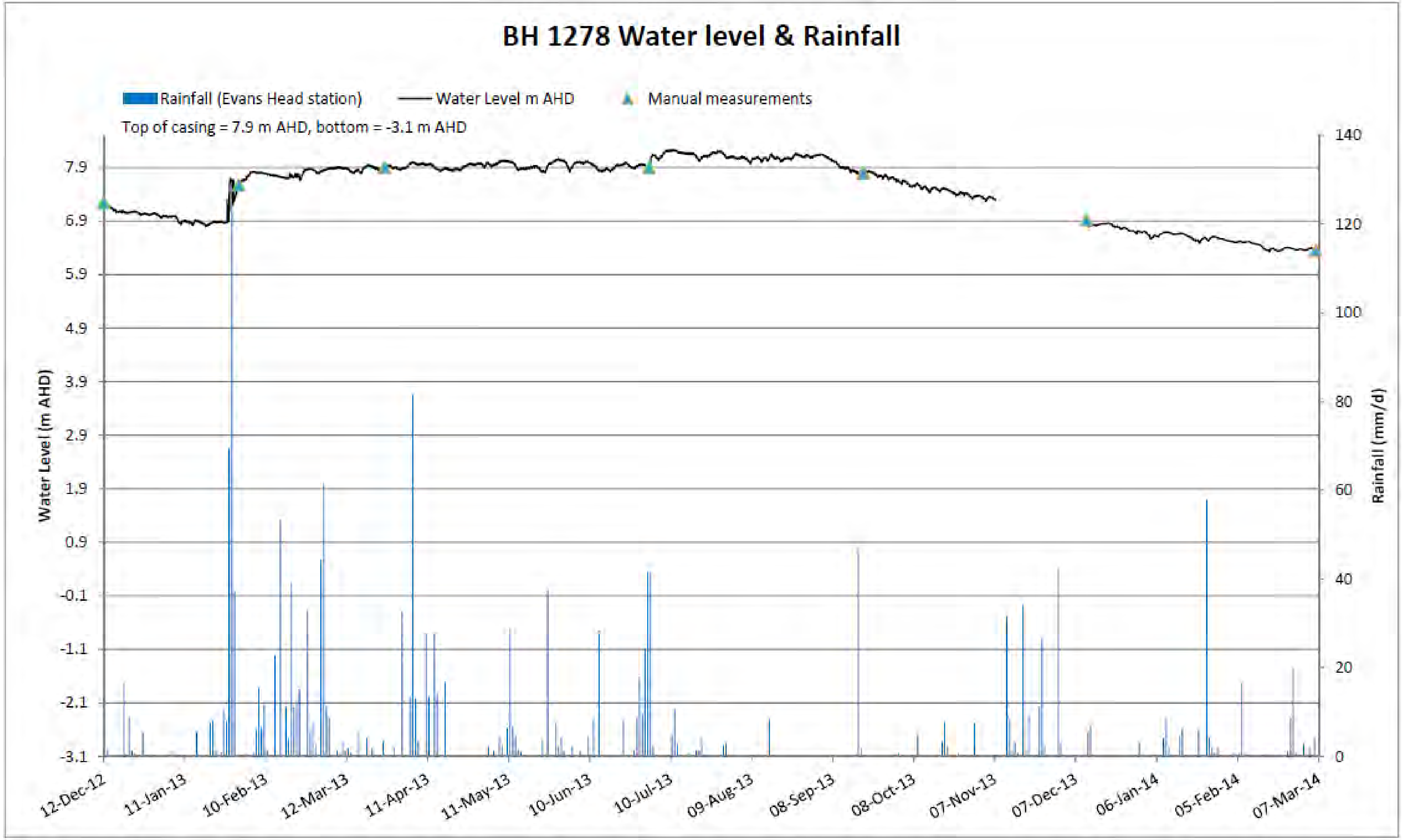
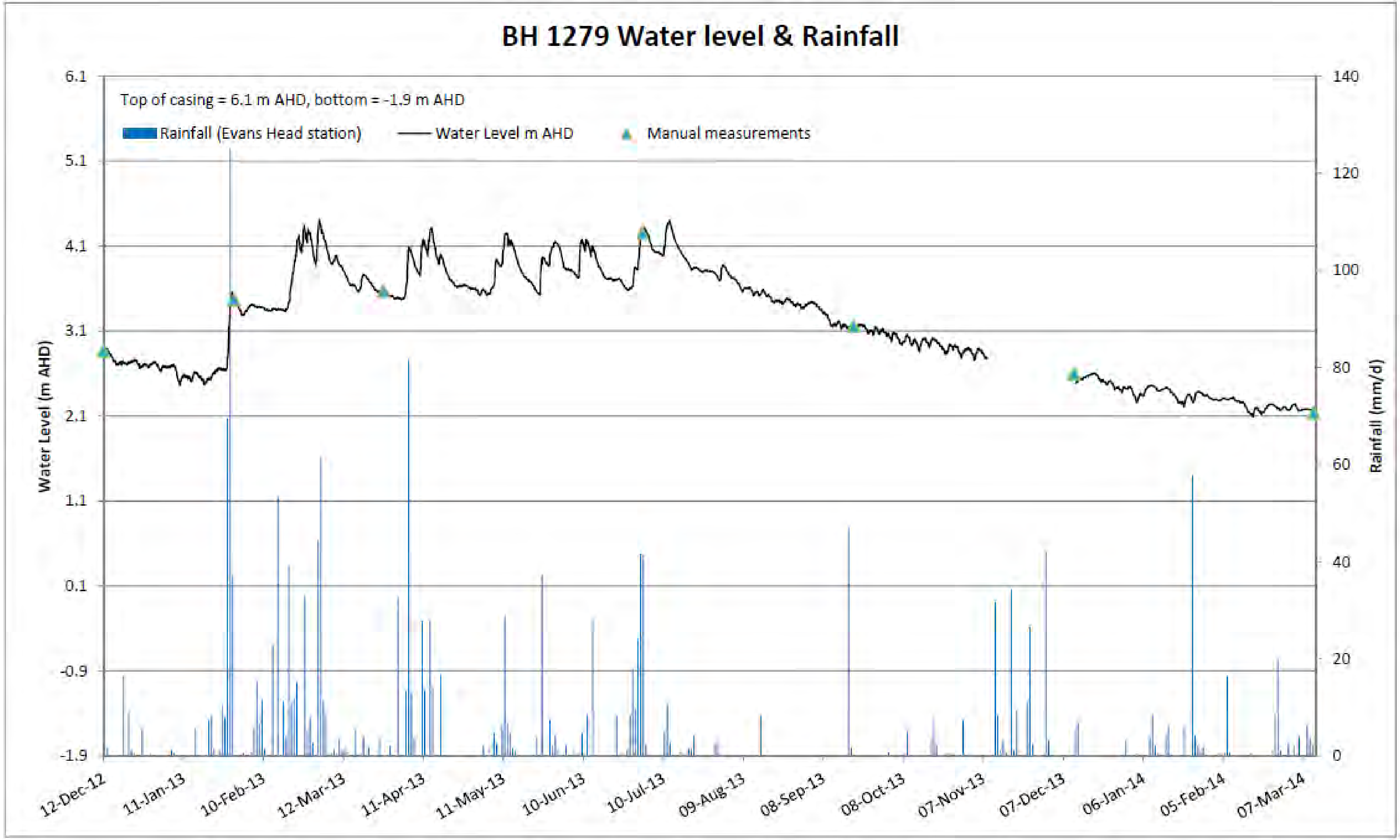
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1277 Water level & Rainfall
Top of casing = 10.5 m AHD, bottom = 3.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
piezometer decommissioned
Water Level (m AHD)
Rainfall (mm/d)
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1278 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 7.9 m AHD, bottom = -3.1 m AHD
Water Level (m AHD)
Rainfall (mm/d)
7.9
6.9
5.9
4.9
3.9
2.9
1.9
0.9
-0.1
-1.1
-2.1
-3.1
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14



BH 1279 Water level & Rainfall
Top of casing = 6.1 m AHD, bottom = -1.9 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
6.1
5.1
4.1
3.1
2.1
1.1
0.1
-0.9
-1.9
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
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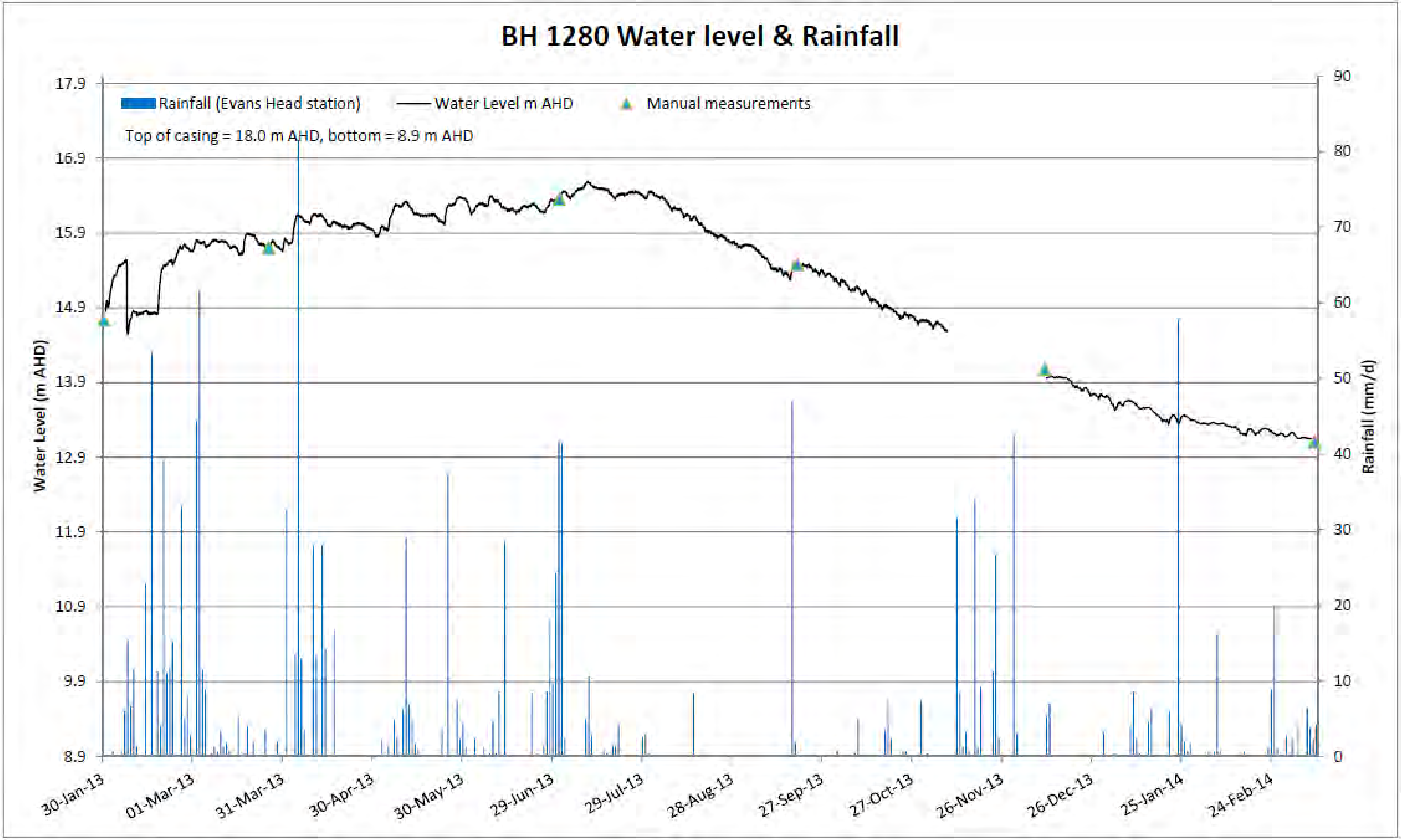
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14



BH 1280 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 18.0 m AHD, bottom = 8.9 m AHD
Water Level (m AHD)
Rainfall (mm/d)
17.9
16.9
15.9
14.9
13.9
12.9
11.9
10.9
9.9
8.9
90
80
70
60
50
40
30
20
10
0
30-Jan-13
01-Mar-13
31-Mar-13
30-Apr-13
30-May-13
29-Jun-13
29-Jul-13
28-Aug-13
27-Sep-13
27-Oct-13
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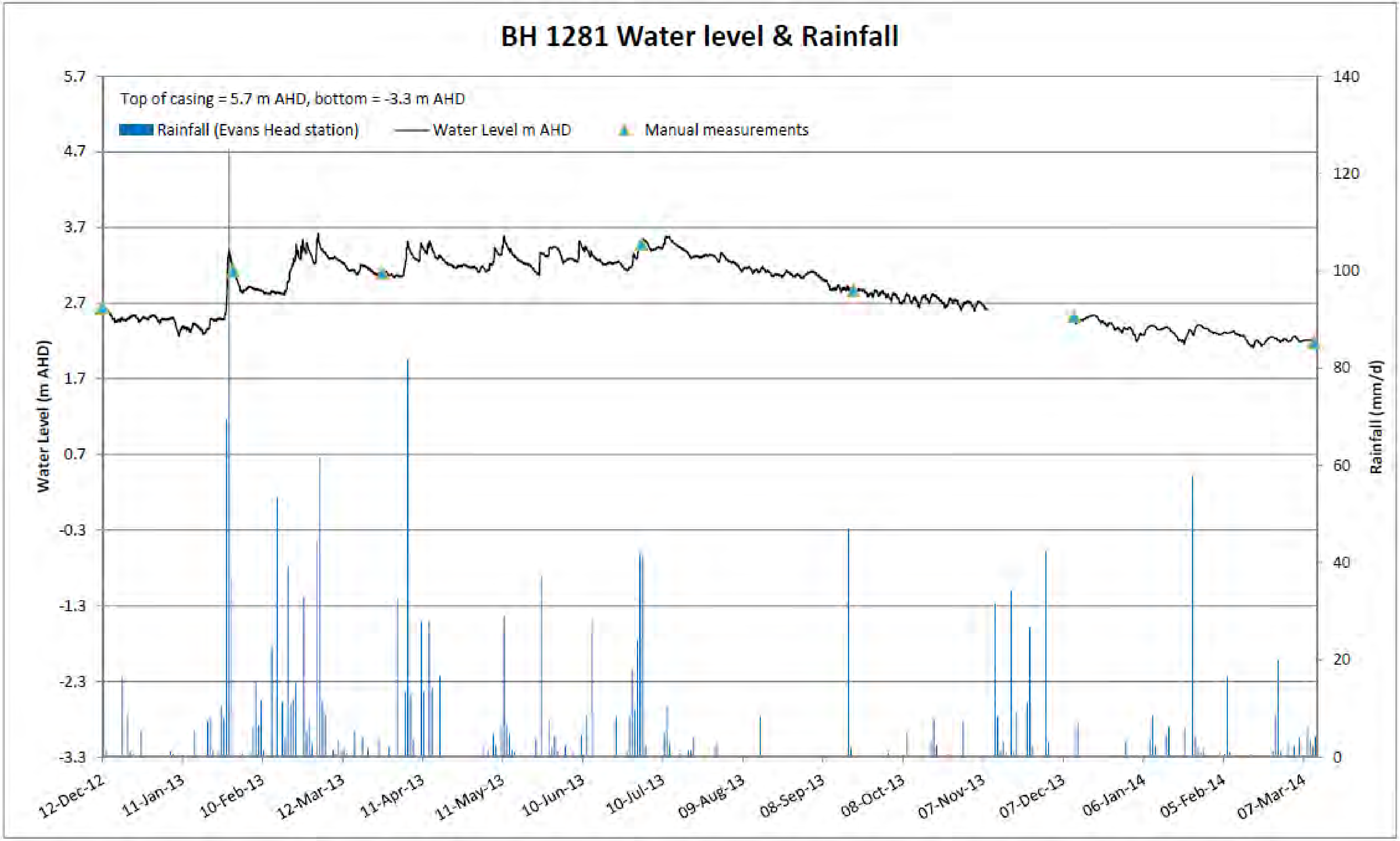
25-Jan-14
24-Feb-14


BH 1281 Water level & Rainfall
Top of casing = 5.7 m AHD, bottom = -3.3 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
5.7
4.7
3.7
2.7
1.7
0.7
-0.3
-1.3
-2.3
-3.3
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
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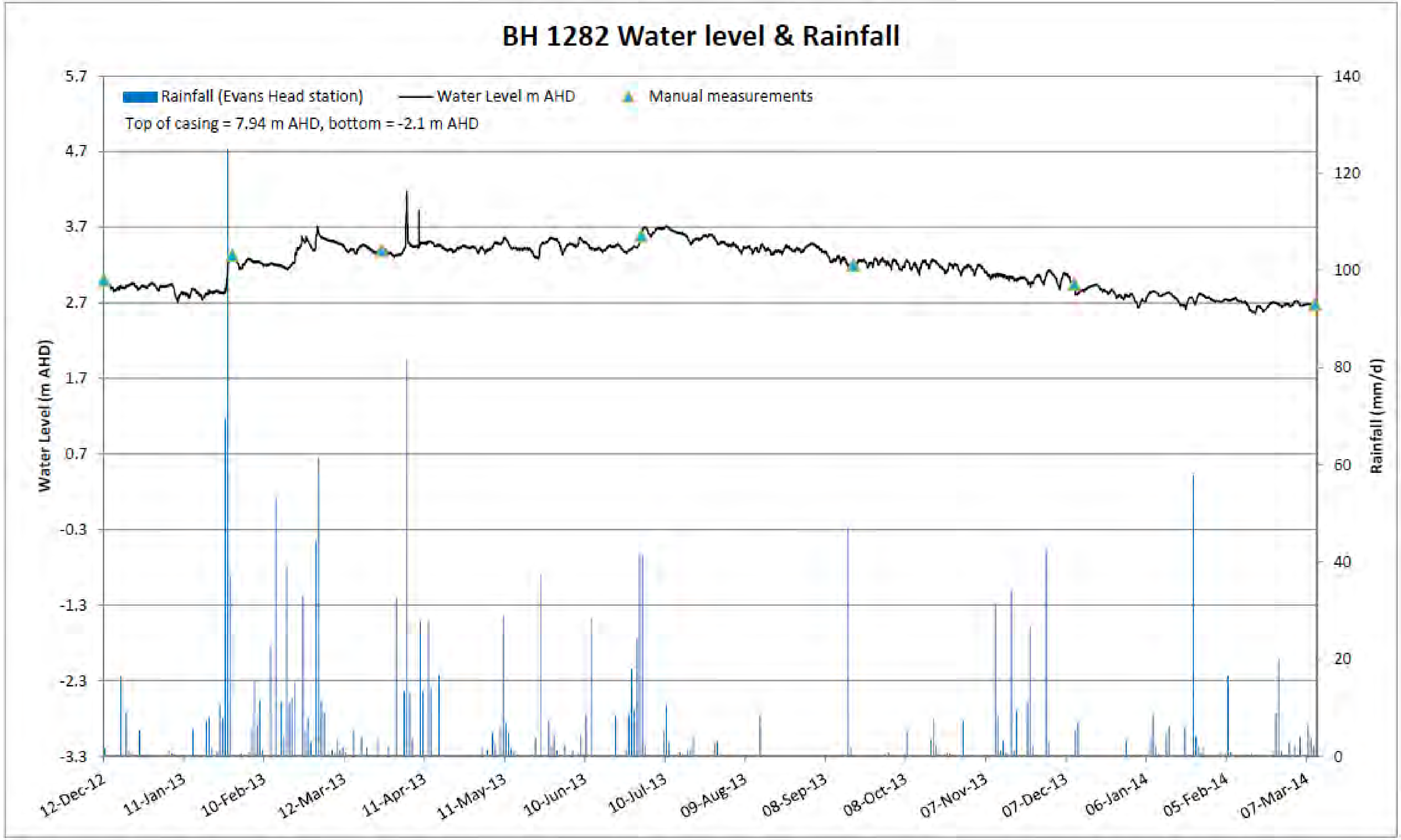
05-Feb-14
07-Mar-14



BH 1282 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 7.94 m AHD, bottom = -2.1 m AHD
Water Level (m AHD)
Rainfall (mm/d)
5.7
4.7
3.7
2.7
1.7
0.7
-0.3
-1.3
-2.3
-3.3
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14

Appendix J

Section 11 - Coolgardie Road to Ballina Bypass: Pre-Construction Monitoring Results

Section 11: Surface Water Monitoring Locations and associated Sensitive Receiving Environments

Surface Water Sample Locations / Waterway	*Sensitive aquatic receiving environments and groundwater dependent ecosystems (GDE's)*
SW15 - Duck Creek	▪ GDE

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 11: Surface Water Monitoring – Overview of Results

Physical properties

Temperature generally exhibited a gradual increase generally from the mid-teens (around 16°C) in winter up to the high-20s (around 29°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. pH levels fell within the range of 4.1 to 9.2.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of <0.01 to 0.46 mg/L. Total Nitrogen values were found to be in the range of <0.1to 0.7 mg/L.

Heavy metals

Heavy metals were not sampled within section 10.

Summary of Visual Observations and Sampling Results

Site Identifier/Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW15/GDE09 Duck Creek Ch. 164,400	▪ No record of visual observations provided.	▪ O&G: <5mg/L ▪ SS: <5-107mg/L ▪ TP: <0.01-0.46mg/L ▪ TN: <0.1-0.7mg/L ▪ DO: 0.5-8.9mg/L ▪ EC: 145-29,500µS/cm ▪ pH: 5.6-7.7 ▪ Temp: 16.2-29.2ºC ▪ NTU: 2.5-38

Note: * Ch. = Highway Chainage

Section 11: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 11							
SW15 (SW11-01 and SW11-02)									
Sample ID Date of Sampling Weather		Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil & Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	23.62	28.91	107.00	2.5	12.0	25.6	-	
Total Phosphorus as P	mg/l	0.16	0.23	0.81	0.0	0.1	0.192	-	
Total Nitrogen as N	mg/l	0.51	0.27	0.80	0.1	0.6	0.7	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.80	2.45	8.90	0.5	7.6	8.56	6	
Conductivity	μs/cm	12746.73	11165.23	31150.00	3.8	10611.0	22188	1216.4	
pH		6.66	0.63	7.50	5.6	6.8	7.22	5.998	
Temperature	°C	23.16	3.58	29.20	16.2	23.1	26.22	-	
Turbidity	NTU	13.96	9.50	38.60	5.8	12.2	17.6	-	

Section 11: Groundwater Monitoring – Water Quality Overview

Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. Prior to measurement, approximately three times the borehole volume of groundwater was purged from each bore. The results for each quarter are shown in the table below.

pH Statistics from Boreholes in Areas of Fill

Borehole Identifier	*Mean (Total)*	*Standard Deviation*	*Min*	*Max*	*Percentile*	
					P80	*P20*
BH1283	6.13	0.28	5.80	6.40	6.15	6.34
BH1284	5.73	0.49	5.00	6.00	5.95	6.00
BH1285	7.40	0.59	6.80	8.20	7.30	7.72
BH1286	7.28	0.50	6.90	8.00	7.10	7.52

Section 11: Groundwater Monitoring – Levels

Summary of Groundwater Level Monitoring – Section 11 DP2B Upgrade

Borehole Identifier	*Typical SWL (m below ground level)*		
	Average	*Median*	*Standard Deviation*
BH1284	-	-	-
BH1285	0.21	0.15	0.64
BH1286	0.68	0.6	0.74

Appendix K

ANZECC Criteria

Surface Water Investigation Levels

Contaminants of Concern	*ANZECC 2000[1] 95% species protected*		*ANZECC 2000 Physico-chemical stressors*	
	Freshwater	*Marine water*	*Freshwater*	*Saltwater/ Estuarine*
Metals				
Arsenic	0.024	0.0023[5]		
Cadmium	0.0002	0.0055		
Chromium	0.001	0.0044		
Copper	0.0014	0.0013		
Lead	0.0034	0.0044		
Mercury	0.0006	0.0004		
Nickel	0.011	0.07		
Zinc	0.008	0.015		
Total Recoverable Hydrocarbons				
Naphthalene	0.016	0.07		
TRH >C10-C16	-	-		
TRH >C10-C16 less Naphthalene	-	-		
TRH >C16-C34	-	-		
TRH >C34-C40	-	-		
TRH C6-C10	-	-		
TRH C6-C10 less BTEX (F1)	-	-		
BTEX				
Benzene	0.95	0.7		
Ethylbenzene	0.08[5]	-		
m&p-Xylenes	-	-		
o-Xylene	0.35	-		
Toluene	0.18[5]	-		
Xylenes - Total	-	-		
Nutrients				
Nitrogen (Total)	-	-	0.5[3]	0.3[3]
Suspended Solids	-	-	< 40[2]	< 10[2]
Phosphorus	-	-	0.05[3]	0.03[3]
Physico-chemical				
Dissolved Oxygen	-	-	> 5[2]	> 5[2]
Electrical conductivity (µS/cm)	-	-	125 – 2,200[4]	-
pH (pH units)	-	-	6.5 - 8[3]	7 – 8.5[3]
Turbidity (NTU)	-	-	50[4]	10[4]

1. Based on ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Fresh & Marine water, South Eastern Australia, slightly to moderately disturbed systems 95% of species protected, see Table 3.4.1).

2. Based on ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Table 4.4.2 Physico-chemical stressor guidelines for the protection of aquaculture species).
3. Based on ANZECC (2000), Australian and New Zealand Guidelines For Fresh and Marine Water Quality (Table 3.3.2 Default trigger values for physical and chemical stressors for south-east Australia)
4. Based on ANZECC (2000) Table 3.3.3 Ranges of default trigger values for conductivity and turbidity indicative of slightly disturbed ecosystems in south east Australia. Note. The maximum values have been adopted for this project.
5. ANZECC (2000) Low reliability trigger values

\- No guideline value is specified.

NB. All units in mg/L unless otherwise stated.

Groundwater Investigation Levels

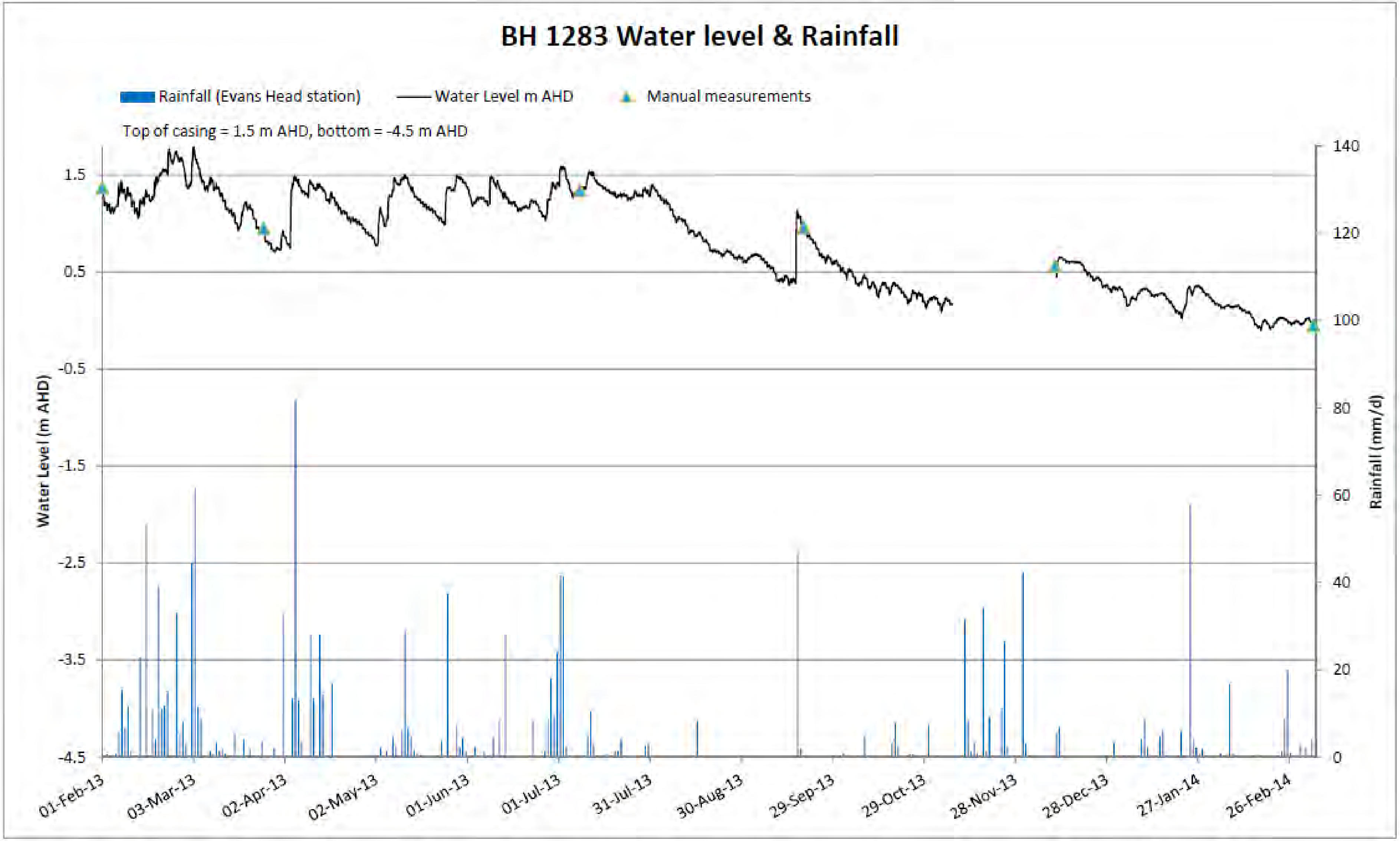
Contaminants of Concern	*ANZECC 2000[1] 95% species*	*Laboratory Limit of reporting*	*Adopted GILs*
Metals			
Antimony	0.009[2]	0.005	0.009
Arsenic	0.024	0.001	0.024
Beryllium	-	0.001	-
Boron	0.37	0.01	0.37
Cadmium	0.0002	0.0001	0.0002
Chromium	0.001	0.001	0.001
Cobalt	-	0.001	-
Copper	0.0014	0.001	0.0014
Lead	0.0034	0.001	0.0034
Manganese	-	0.001	-
Mercury	0.0006	0.0001	0.0006
Molybdenum	-	0.001	-
Nickel	0.011	0.001	0.011
Selenium	-	0.005	-
Silver	0.00005	0.0001	< LOR
Tin	0.003[2]	0.005	0.005
Zinc	0.008	0.005	0.008
Inorganics			
Cyanide	0.007	0.005	0.007
Total Recoverable Hydrocarbons			
TRH C6-C10	-	0.002	< LOR
TRH C6-C10 less BTEX (F1)	-	0.002	< LOR
TRH >C10-C16	-	0.05	< LOR
TRH >C10-C16 less Naphthalene (F2)	-	0.05	< LOR
TRH >C16-C34	-	0.1	< LOR
TRH >C34-C40	-	0.1	< LOR
BTEX			
Benzene	0.95	0.001	0.95
Ethylbenzene	0.08[2]	0.001	0.08
m&p-Xylenes	-	0.002	-
o-Xylene	0.35[2]	0.001	0.35
Toluene	0.18[2]	0.001	0.18
Xylenes - Total	-	0.003	-
Polycyclic Aromatic Hydrocarbons			

Contaminants of Concern	*ANZECC 2000[1] 95% species*	*Laboratory Limit of reporting*	*Adopted GILs*
Acenaphthene	-	0.001	-
Acenaphthylene	-	0.001	-
Anthracene	-	0.001	-
Benz(a)anthracene	-	0.001	-
Benzo(a)pyrene	0.0002[2]	0.001	< LOR
Benzo(b)fluoranthene &	-	0.001	-
Benzo(g.h.i)perylene	-	0.001	-
Chrysene	-	0.001	-
Dibenz(a.h)anthracene	-	0.001	-
Fluoranthene	0.0014[2]	0.001	0.0014
Fluorene	-	0.001	-
Indeno(1.2.3-cd)pyrene	-	0.001	-
Naphthalene	0.016	0.001	0.016
Phenanthrene	0.002[2]	0.001	0.002
Pyrene	-	0.001	-
Total PAH	-	0.001	< LOR
Phenols			
Phenolics (Total)	0.32	0.002	0.32
Organochlorine Pesticides			
4.4'-DDD	-	0.0001	-
4.4'-DDE	-	0.0001	-
4.4'-DDT	0.00001	0.0001	< LOR
a-BHC	-	0.0001	-
Aldrin	-	0.0001	-
b-BHC	-	0.0001	-
Chlordanes - Total	0.00008	0.001	< LOR
d-BHC	-	0.0001	-
Dieldrin	-	0.0001	-
Endosulfan I	-	0.0001	-
Endosulfan II	-	0.0001	-
Endosulfan sulphate	-	0.0001	-
Endrin	0.00002	0.0001	< LOR
Endrin aldehyde	-	0.0001	-
Endrin ketone	-	0.0001	-
g-BHC (Lindane)	0.0002	0.0001	0.0002
Heptachlor	0.00009	0.0001	< LOR
Heptachlor epoxide	-	0.0001	-
Hexachlorobenzene	-	0.0001	-
Methoxychlor	-	0.0001	-
Toxaphene	-	0.0001	-
Polychlorinated Biphenyls			
Aroclor-1016	-	0.005	-
Aroclor-1232	-	0.005	-
Aroclor-1242	0.0006	0.005	< LOR
Aroclor-1248	-	0.005	-

Contaminants of Concern	***ANZECC 2000[1] 95% species***	***Laboratory Limit of reporting***	***Adopted GILs***
Aroclor-1254	0.00003	0.005	< LOR
Aroclor-1260	-	0.005	-
Total PCB	-	0.005	< LOR

1. Based on ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Fresh & Marine water, South Eastern Australia, slightly to moderately disturbed systems 95% of species protected, see Table 3.4.1).

ANZECC (2000) Low reliability trigger values NB. All units in mg/L unless otherwise stated.


BH 1283 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.5 m AHD, bottom = -4.5 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.5
0.5
-0.5
-1.5
-2.5
-3.5
-4.5
140
120
100
80
60
40
20
0
01-Feb-13
03-Mar-13
02-Apr-13
02-May-13
01-Jun-13
01-Jul-13
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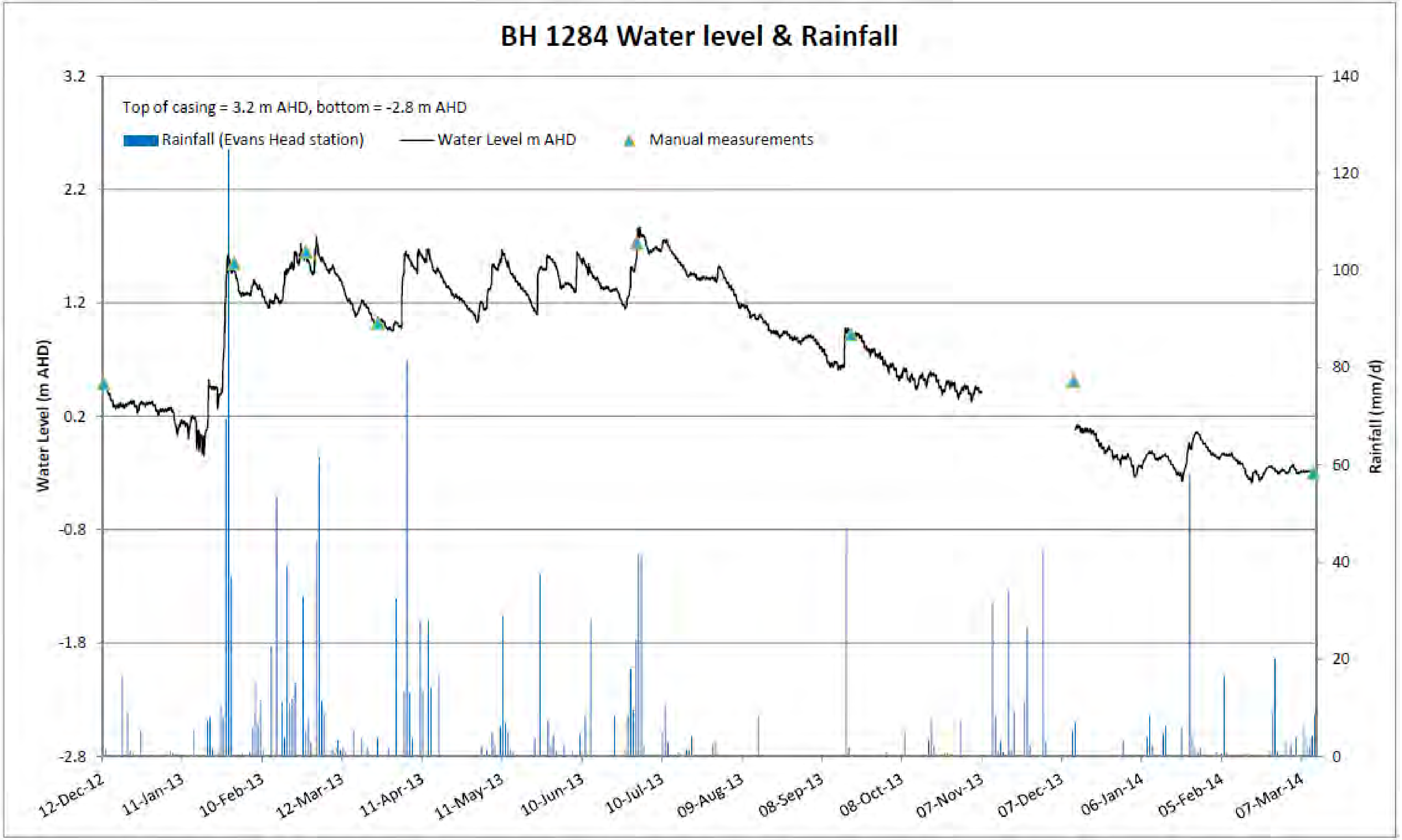
27-Jan-14
26-Feb-14



BH 1284 Water level & Rainfall
Top of casing = 3.2 m AHD, bottom = -2.8 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.2
2.2
1.2
0.2
-0.8
-1.8
-2.8
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
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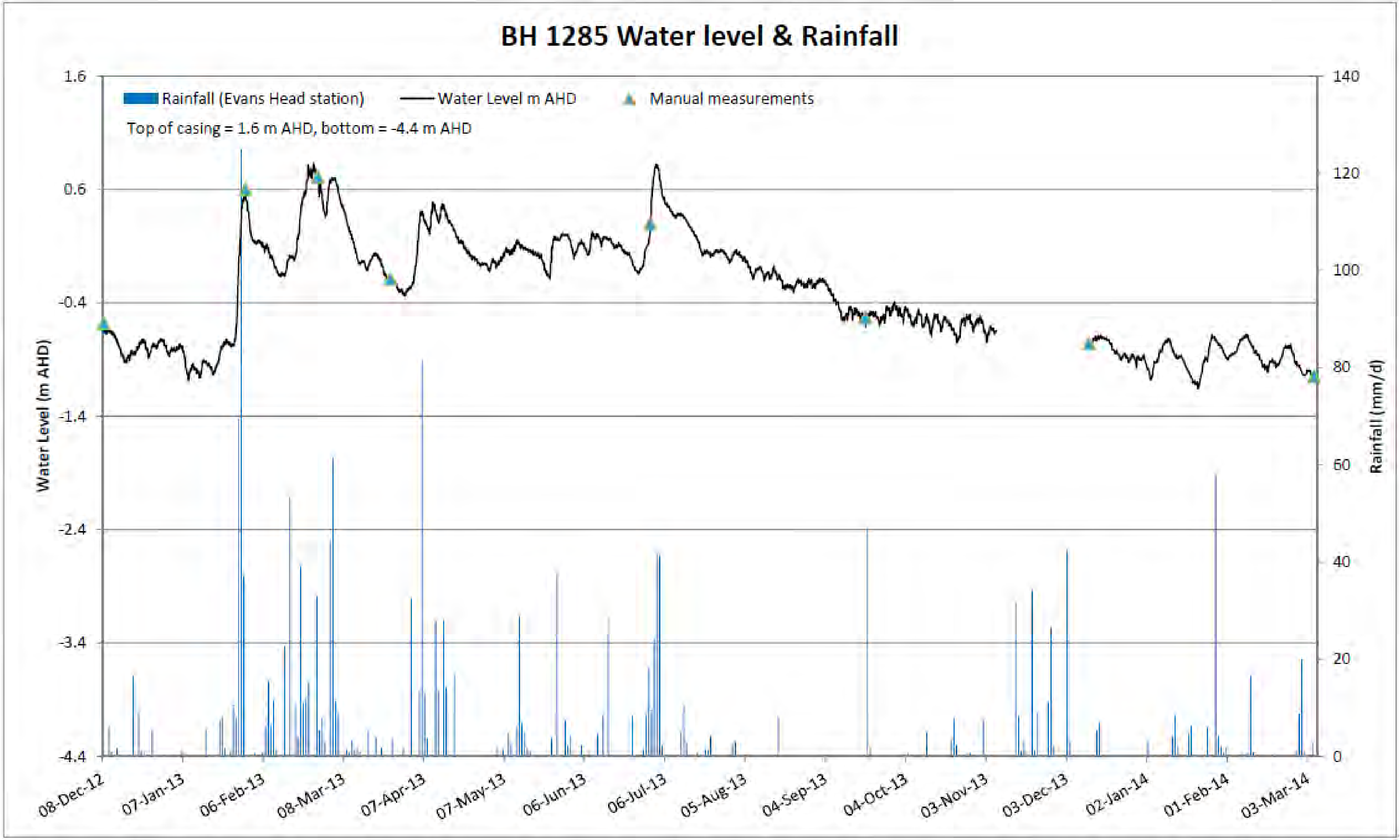
06-Jan-14
05-Feb-14
07-Mar-14


BH 1285 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.6 m AHD, bottom = -4.4 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
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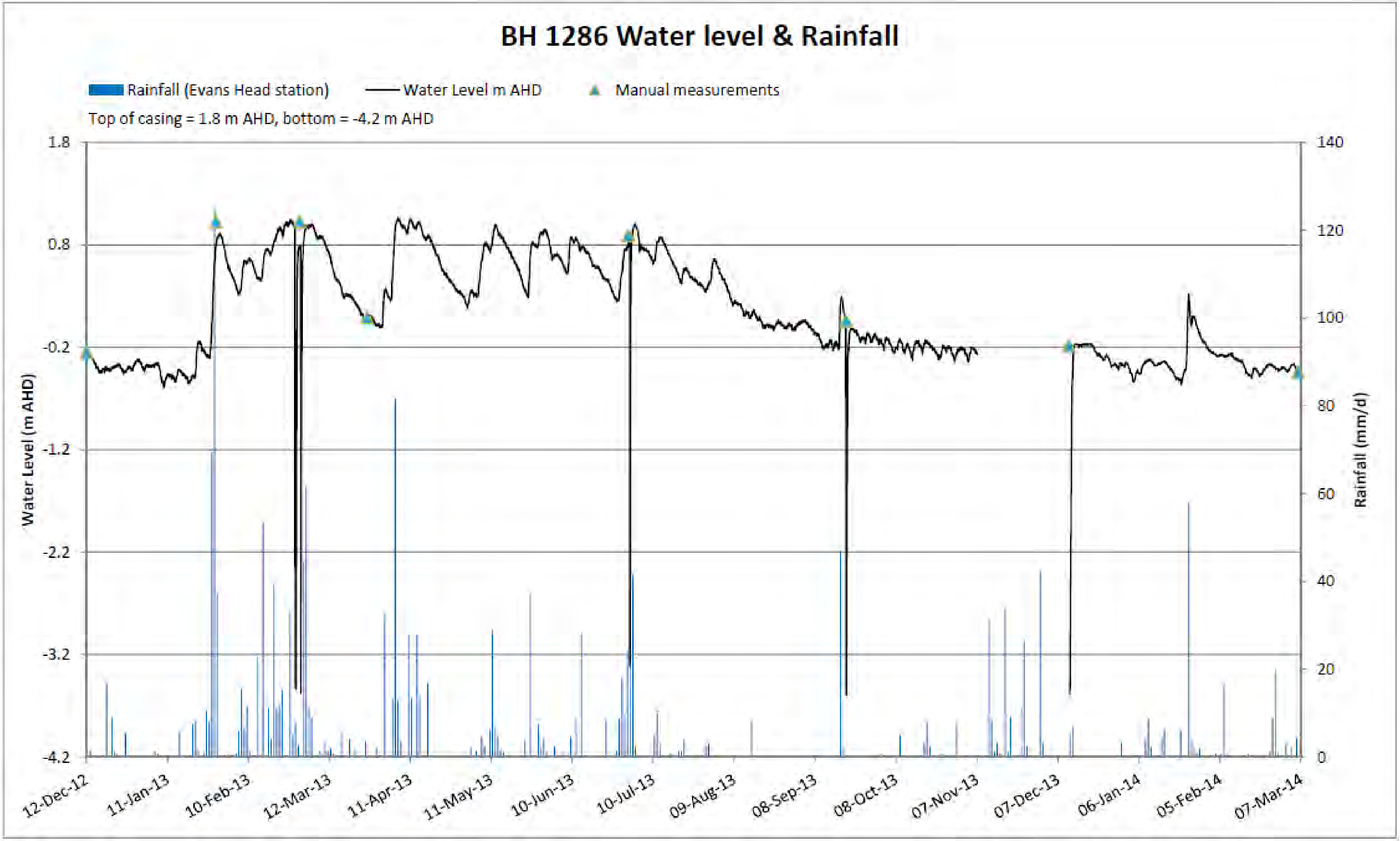
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1286 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.8 m AHD, bottom = -4.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.8
0.8
-0.2
-1.2
-2.2
-3.2
-4.2
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14

Appendix B
Spoil and Fill Management Procedure

GOLDING

CONSTRUCTION PROCEDURE
SPOIL AND FILL MANAGEMENT

Purpose: This Procedure describes the process to ensure that all spoil is either reused on-site or disposed off site in accordance with its waste classification. The instruction will ensure that all wastes are handled in accordance with contractual requirements and identified legislation, codes and manuals.

Project No.:	RMS 00031	**Project Description:**	Pacific Highway Upgrade - Woolgoolga to Ballina Early Works – Wave 1 and Wave 3 (part)
Scope of Procedure	This Procedure is applicable to all earthworks on the project. ***Resource recovery orders and exemptions*** Under the new provisions of the 2014 Waste Regulation, the EPA will now issue two separate documents: a resource recovery order and a resource recovery exemption. (These replace the previous Resource Recovery Exemption system.) Resource recovery orders include conditions which generators and processors of waste must meet to supply the waste for land application, use as fuel or in connection with a process of thermal treatment. They may include specifications, record-keeping, reporting and other requirements. All resource recovery orders are made under clause 93 of the 2014 Waste Regulation. Resource recovery orders and resource recovery exemptions are issued by the NSW Environment Authority (EPA) by notice in the NSW Government Gazette and are published below on the EPA website. Resource recovery exemptions contain the conditions which consumers must meet to apply waste to land outside certain requirements of the waste regulatory framework. They may include requirements on how to re-use or apply the waste, and record-keeping, reporting and other requirements. All resource recovery exemptions are made under clauses 91 and 92 of the 2014 Waste Regulation. Resource recovery orders and resource recovery exemptions do not release those using them from complying with relevant planning consent requirements. If you wish to use an order or exemption, it is your responsibility to seek any necessary development consents from the appropriate regulatory authority. ***Contaminated Material*** Potentially contaminated material will be classified in accordance with the EPA Waste Classification Guidelines Part 1: Classifying Waste (EPA 2014) and incidental finds managed in accordance with Appendix B7 Construction Waste and Energy Management Plan.		

Procedure

1. Classification of Spoil
Project Engineers are responsible for spoil classification. Spoil will be classified as one of the following spoil types: • Virgin Excavated Natural Material (VENM) • Excavated Natural Material (ENM) • Topsoil • Acid Sulphate and Potential Acid Sulphate Soil • Potentially Contaminated Material • Excavated public road material. Further information is provided following on the spoil types and reuse options. If required, the Environmental Site Representative (ESR) can provide assistance with spoil classification **1.1. VIRGIN EXCAVATED NATURAL MATERIAL (VENM)** • Defined as natural material (such as clay, gravel, sand, soil or rock fines):

  - That has been excavated or quarried from areas that are not contaminated with manufactured chemicals or process residues, as a result of industrial, commercial, mining or agricultural areas, and
  - That does not contain any sulphidic ores or soils or any other waste (POEP Act definition).
- Excavated material will be confirmed as VENM through visual observation of landform, understanding of past land-uses, and based on findings from geotechnical reports. If there is still uncertainty whether excavation material is VENM, laboratory analysis may be undertaken.
- Excavated material which has been stored or processed in any way cannot be classified as VENM.
- Where an excavated material cannot be classified as VENM, it may be classified as ENM (refer to Section 1.2 following).
- EPA places no specific restrictions on reuse options for VENM.
- Further information on spoil classification as VENM can be found in Fact sheet: Virgin excavated natural material (DECC, 2008).

1.2. EXCAVATED NATURAL MATERIAL (ENM)

- Defined as naturally occurring rock and soil (including but not limited to materials such as sandstone, shale, clay and soil) that has:

  a) Been excavated from the ground, and
  b) Contains at least 98% (by weight) natural material, and
  c) Does not meet the definition of VENM in Section 1.1.

  ENM does not include material that has been processed or contains acid sulphate soils (ASS) or potential acid sulphate soils (PASS)

  (Definition from 'The excavated natural material exemption 2008' of the PoEO (Waste) Regulation).
- EPA places no specific restrictions for onsite reuse of ENM, however if reuse offsite is being considered, testing must be undertaken and an exemption obtained under the PoEO (Waste) Regulation in accordance with the Guidelines on Resource Recovery Exemptions (Land Application), (2008).

1.3. TOPSOIL

- Before stripping topsoil seek approval from the Principal.
- To be undertaken in accordance with RMS R178, summarise below.
- As far as practical topsoil shall not be stripped from areas of embankment construction, including stability berms.

Topsoil from Native Bushland Areas

- Following clearing and grubbing remove top 100mm of soil and dispose of as spoil as per RMS R44.
- Strip remaining topsoil and vegetate in accordance with Clause 6 Temporary Vegetation. Maintain sufficient temporary vegetation cover to minimise colonisation by weed species.

Topsoil from Agricultural Areas

- Prior to clearing and grubbing, spray all vegetation with herbicide, wait two weeks, spray again wait further two weeks.
- Following clearing and grubbing remove top 100mm of soil and dispose of as spoil as per RMS R44.
- Strip remaining topsoil and vegetate in accordance with Clause 6 Temporary Vegetation. Maintain sufficient temporary vegetation cover to minimise colonisation by weed species.

Stockpiling

- Topsoil is to be reused only within the site that it was stripped from, protected from windblown seed and with a maintained perimeter to minimise weed colonisation from adjacent sources.
- Stockpile sites are to be approved by the Principal.
- Stockpile heights to be no greater than 2 metres, unless otherwise approved by the Principal and slopes no steeper than 2:1.

Reuse of Topsoil

- Reuse of topsoil is in accordance with RMS R38, R44 and R178

- Where necessary, advice must be sought from a qualified Landscape Officer in order to determine whether the type and/or proportion of weed cover is significant for the purposes of the definition in R178
- As necessary use a NATA accredited testing laboratory to ascertain suitability of stockpiled topsoil for use in revegetation works.

1.4. ACID SULFATE AND POTENTIAL ACID SULFATE SOIL

- Acid sulphate and potential acid sulphate soils will be identified as per Procedure - Acid Sulphate Material Unexpected Find. All acid sulphate soils will be transported to an approved ASS treatment area where treatment will occur as per Procedure – Treatment of Acid Sulphate Material.
- Verified treated ASS may be reused onsite (verified in accordance with Procedure – Treatment of Acid Sulphate Material)

1.5. POTENTIALLY CONTAMINATED MATERIAL

- Potentially contaminated material may be identified during the course of the Project and will be handled in accordance with Appendix B10 Construction Contaminated Land Management Plan which describes the specific management measures and disposal options according to the EPA waste guidelines.

1.6. EXCAVATED PUBLIC ROAD MATERIAL (EPRM)

- Defined as:
  - being rock, soil, sand, bitumen, reclaimed asphalt pavement, gravel, slag from iron and steel manufacturing, fly and bottom ash, concrete, brick, ceramics and materials that hold a resource recovery order for use in road making activities; and
  - that have been excavated during the construction and maintenance of council and RMS public roads and public road infrastructure facilities.
- The excavated public road material can only be applied to land within the road corridor for public road related activities including road construction, maintenance and installation of road infrastructure facilities.
- The excavated public road material can only be stored within the road corridor at the site where it is to be applied to land.
- The excavated public road material cannot be applied to private land.
- The consumer must ensure that any application of excavated public road material to land must occur within a reasonable period of time after its receipt.

2. Reuse

Reuse of spoil will be in accordance with "Management of Surplus Material" in Section 3.9 of the Submissions/PIR.

Potentially contaminated material will be managed in accordance with Appendix B7 Construction Waste and Energy Management Plan.

3. Transport of Spoil and Fill Material

Comply with the requirements of the POEO Act not to cause actual or potential harm to the environment when disposing of and transporting surplus materials, including excavated materials. Dispose to a place that can lawfully accept the waste.

Securing tailgates and cover loads that are to be carried on public roads or near residential areas (prior to transportation) to suppress dust generation, prevent spillage, loss of construction materials or waste and to prevent emission of odours.

Potentially contaminated material will be managed and transported in accordance with Appendix B7 Construction Waste and Energy Management Plan.

4. Disposal from Site

Where spoil is to be disposed of, it must be classified in accordance with the waste classification procedure and disposal in accordance with the Appendix B7 Construction Waste and Energy Management Plan.

Appendix C
Acid Sulfate Soil Management Procedure

Note: Acid sulphate soil management has been covered in a separate management plan (Appendix B11) and associated procedures are contained in that plan.

Appendix D
Management of tannins from vegetation mulch

Transport
Roads & Maritime
Services

ENVIRONMENTAL DIRECTION

Management of Tannins from Vegetation Mulch

JANUARY 2012

ABOUT THIS RELEASE

Environmental Direction number	25
Environmental Direction title	Management of Tannins from Vegetation Mulch
Author	Environment Branch (Environmental Policy)

Issue	Date	Revision description
1	December 2011	Final draft
2	January 2012	Final

CONTENTS

1 PURPOSE

The purpose of this environmental direction is to set RMS's minimum management measures to minimise the generation and discharge of tannins from vegetation mulch on Roads and Maritime Services (RMS) construction projects. Additional background information on tannins and the use of mulch on construction sites is included in section 3 of this direction.

2 MANAGEMENT MEASURES

The primary focus must be to minimise tannin generation on construction sites.

2.1 General mulch management measures

These general mulch management measures are to be followed for all RMS construction projects.

2.1.1 Planning and works staging

The first step in planning and works staging is to identify the amount of mulch to be generated. With this information, a strategy can be prepared to manage mulch on site. Staging of chipping, tub grinding and/or mulching activities should be planned to reduce the volume of mulch to be managed at any one time. The volume of excess mulch can then be assessed and plans made to dispose of this off site.

Other general considerations at the planning and works staging phase are as follows:

- Mulch stockpile sites should be established with appropriate controls in place before the main site clearing activities commence. Limited clearing may be required earlier for establishment of stockpile areas and access.
- Stage the mulching of cleared vegetation to ensure that mulch can be progressively moved to elevated, or otherwise suitable, stockpile locations. It is preferred that mulch should be transferred to a stockpile or reused on the day of mulching.
- Plan to efficiently reuse mulch in progressive works to reduce the time that mulch is concentrated in stockpile locations.
- Excess mulch can be managed by community giveaway. This takes considerable time and mulch needs to be suitably located and managed as this occurs. The conditions for community giveaway of mulch are included as Appendix 3.
- Any other form of bulk offsite mulch disposal (eg to Council parkland or a development site) must be assessed to ensure waste management provisions are adhered to for off site disposal.

2.1.2 Stockpile location and management

- Mulch stockpile sites should be established on elevated ground where possible.
- Stockpile sites with a duration of not more than 1 month should be constructed not less than 20 metres from a watercourse, including floodplains.
- Stockpile sites with a duration of more than 1 month should be constructed not less than 50 metres from a watercourse, including floodplains.
- Mulch stockpiles should be designed and constructed to divert upgradient water to prevent it from entering the stockpile site.

2.1.3 Management measures for the use of mulch on site

- Do not use mulch for surface cover or sedimentation controls in any low lying areas of the site that remain consistently wet. Alternative controls such as geofabric (for surface protection) or sediment fence will be required in these areas.
- Do not spread surface mulch in thicker than 100mm layers. Mixing mulch with topsoil is encouraged for batters to prevent loss of topsoil during initial stabilisation. It should be noted that mulch will generally cause nitrogen draw down which may inhibit plant growth, unless mulch has been composted first.
- Care is to be taken to ensure that excessive mulch is not applied for sedimentation controls such as perimeter bunds or catch dams.

2.1.4 Monitoring and response

- Monitor the site for generation of tannins. Tannin impacts can be readily identified visually as dark coloured ponded water. Site staff should be trained to identify and report potential impacts to the site project management or environment staff.
- Review management practices where required to prevent the generation of tannins in identified problem areas.

2.2 Mulch management methods for high risk sites

2.2.1 High risk sites

High risk sites, where additional management measures may be required, include:
- where large quantities of mulch will be generated and stockpiled.
- where high tannin generating vegetation types are to be mulched (see 3.1).
- where the receiving environment is identified as sensitive (eg Marine Park, threatened aquatic species habitat).
- where tannins have been observed to be generated or discharged from an operating site with standard management controls.

2.2.2 Stockpile management measures for high risk sites

- Mulch stockpiles for high tannin generating vegetation types should incorporate an impermeable bund to capture stockpile leachate or tannin impacted water. Impervious bunds must be a minimum of 300 mm high, preferably higher to capture tannin impacted water. All bunded stockpiles that are in place for a period longer than one month must include a lined discharge point for overflow in extreme rainfall events.
- Stockpiles established on sloping sites must be designed to provide temporary stormwater containment equivalent to a 300 mm minimum height bund on a flat site.
- Tannin impacted water should be pumped out of bunded stockpiles within 5 days of the end of a rainfall event to maintain the storage capacity. This water should be used for on site purposes including dust suppression and landscape watering. These activities must be managed to prevent any pooling or runoff of tannin impacted water.
- Bunded stockpiles must be inspected within 24 hours of cessation of any rainfall event greater than 10mm to ensure tannin impacted water does not overflow.

2.3 Site management procedures

Site management procedures must be prepared for all sites where tannins are identified as a potential issue. Site management procedures should be based on the management measures provided in this Environmental Direction.

3 BACKGROUND

3.1 Tannin generation from vegetation mulch

See Plates 1 – 3 in Appendix 1.

Tannins are naturally occurring plant compounds. Tannin generation from vegetation mulch is likely to be highest from low-lying coastal floodplain areas. The species of vegetation (eg *Melaleuca*) will have a major impact on the likelihood of tannin generation.

Tannin generation is generally highest from mulched vegetation that is stockpiled in areas that are subject to inundation. Placement in wet areas will result in accelerated leaching of tannins into water, concentration of tannins in pooled water, and greater impacts on water quality.

3.2 Tannin impacts on water quality

See Plates 4 – 5 in Appendix 1.

The main concern with the discharge of water that is high in tannins is that it may increase the biological oxygen demand (BOD) of the receiving environment. Increases in BOD may result in a decrease in available dissolved oxygen. A lack of dissolved oxygen is identified as the main cause of about 80 percent of fish kills in NSW rivers and estuaries.

Tannin impacts may result in dark coloured water discharge from construction sites. This impact can be obvious and may raise the concern of the community and other stakeholders including regulatory authorities. Once discharged to the environment, tannins may reduce visibility and light penetration and change the pH of receiving waters. These impacts may affect aquatic ecosystems in receiving environments.

Tannins cannot be readily treated with standard construction site water quality controls. Once water on site is impacted with tannins it is not possible to treat effectively with currently approved flocculants. Minimisation of tannin generation in the first place is the management strategy that must be applied.

3.3 Use of mulch on construction sites

See Plates 10 – 16 in Appendix 2.

The RMS Biodiversity Guidelines provide guidance on the benefits of reusing various sizes of vegetation for different purposes. Mulch is a readily available and cheap source of material for temporary site stabilisation and sedimentation control. The re-use of mulch reduces the need to transport this material off-site and reduces handling and disposal costs for construction contracts.

Unprotected mulch sedimentation controls should not be placed in concentrated flow lines where mulch may be washed away. Mulch may be protected by wrapping it with geofabric or other materials to provide a stable control. All temporary catch dams constructed from mulch must have a stable outlet to minimise the washing away of mulch in high rainfall events, and the possible failure of the control.

4 ADDITIONAL RESOURCES

- RTA Biodiversity Guidelines- Protecting and Managing Biodiversity on RTA Projects, 2011
- Pacific Highway Mulch Protocol 2011

5 APPENDICES

Appendix 1: Plates showing tannin generation & water quality impacts

Plate 1: Melaleuca vegetation community – mulch from this vegetation type will generally produce high amounts of tannins.

Plate 2: Vegetation mulching activity – mulch should be progressively moved into prepared stockpile areas.

Plate 3: Tannin generation from recently felled and partially mulched vegetation in an area subject to localised inundation. Mulched vegetation should be progressively moved to prepared stockpiles to manage tannin impacted water.

Plate 4: Tannin impact in stormwater at the discharge point from a road construction site. The discharge of impacted water may be obvious to community and other stakeholders.

Plate 5: Tannins in a drainage line generated from very thickly applied mulch on the batter above. Note that the sedimentation fence is not effective in treating the tannins.

Appendix 2: Plates showing the use of mulch for erosion & sedimentation controls

Plate 6: Mulched vegetation stockpiled in a low-lying area subject to inundation. This is not an appropriate stockpile location and may increase the generation of tannins from stockpiled mulch.

Plate 7: Mulch being placed as batter erosion control. Mulch should not be applied in layers more than 100 mm thick for surface stabilisation.

Plate 8: Site showing recent application of a mulch/topsoil mix on batters (40% mulch to 60% topsoil). Mulch mixes are used to provide temporary stabilisation to prevent the loss of topsoil from batters in heavy rainfall events. Mulch use is also shown as a mounded sedimentation control to prevent sediment entering the median drain.

Plate 9: A mulch/topsoil mix used to provide temporary batter stabilisation and to assist cover crop establishment.

Plate 10: Successful establishment of cover crops on batters where mulch has been used with topsoil to assist temporary stabilisation.

Plate 11: Geofabric wrapped mulch bunds used for sedimentation control

Plate 12: Mulch used as a bund for a temporary sedimentation catch dam. Mulch is effective as it can provide both containment and filtering of site water. Mulch should not be used as a control in areas of concentrated flow where it may be washed away. Any mulch containment control should have a defined and lined outlet that allows discharge from the control without washing mulch away. Note that this control does not have a defined discharge outlet which should be installed to prevent failure of the control in heavy rainfall events.

Appendix 3: Minimum requirements for community mulch giveaways

The purpose of community mulch giveaways is to provide mulch for residential landscaping purposes.

The activities of a community mulch giveaway are permissible under the *Protection of the Environment Operations (Waste) Regulation 2005 – General Exemption Under Part 6, Clause 51 and 51A* (the Raw Mulch Exemption 2008). However, the activities remain subject to other relevant environmental regulations within the Act and Regulations. The Raw Mulch Exemption 2008 is subject to the following conditions:

- The raw mulch can only be applied to land for the purposes of filtration or as a soil amendment material or used either singularly or in any combination as input material(s) to a composting process.
- The consumer must land apply the raw mulch within a reasonable period of time.

Further information can be found at: www.environment.nsw.gov.au/resources/waste/ex08mulch.pdf

It is the mulch generators responsibility to ensure that the mulch is reused in an environmentally responsible manner.

A safe work method statement (SWMS) must be prepared that identifies potential OHS risks and all prevention and mitigation measures. The SWMS must apply to both the community and site workers involved in the mulch giveaway.

Each member of the community who participates in the mulch giveaway must read and understand a site specific information sheet. A template information sheet is attached as Appendix 4.

The site occupier must maintain written records for each load of mulch that is taken away and to ensure that each community participant understands the conditions of the community mulch giveaway information sheet. A suggested template to record this information is attached as Appendix 5.

Appendix 4: Community mulch giveaway information sheet

The following community mulch giveaway information sheet must be populated with site specific information.

Community Mulch Giveaway
Information Sheet

Details of Mulch Supply	
Site Occupier	<insert name of contractor / alliance etc>
Project Name	<insert project name>
Location	<insert location of mulch stockpile>
Mulch stockpile access directions	<insert adequate directions for community members to find the stockpile location>

Background

- This information sheet supports the non-commercial giveaway of mulch for local residents.
- The product is raw vegetation mulch from <insert project location / name>.

Conditions

- Any one individual may only take a maximum of 5 trailer loads from this project.
- The mulch may only be used for residential landscaping purposes.
- Mulch must not be placed in or immediately adjacent to waterways.
- The raw mulch can only be applied to land for the purposes of filtration or as a soil amendment material or used either singularly or in any combination as input material(s) to a composting process.
- The consumer must apply the raw mulch to land within a reasonable period of time.

Community Safety Requirements

- <add in any safety requirements or mitigation measures from the SWMS that apply to the community>
- <add in any safety requirements or mitigation measures from the SWMS that apply to the community>
- <add in any safety requirements or mitigation measures from the SWMS that apply to the community>
- <add in any safety requirements or mitigation measures from the SWMS that apply to the community>

Appendix 5: Records template for community mulch giveaway

The records in the following suggested template must be kept as a minimum.

Community Mulch Giveaway Record Sheet				
Date	**Car Registration**	**I have read and understand the 'Community Mulch Giveaway Information Sheet'**	**Name**	**Signature**
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		

Appendix E
Groundwater Management Strategy

Not Applicable: The Water Quality Monitoring Program prepared by RMS for Section 3-11 cover groundwater monitoring requirements

Appendix F
Unexpected Discovery of Contaminated Land Procedure

Note: Contaminated land management has been covered in a separate management plan (Appendix B10) and associated procedures are contained in that plan.

Appendix G
Pacific Highway Projects Dewatering Practice Note

DEWATERING PRACTICE NOTE

Pacific Highway Projects

May 2012

Document control

Document Title	Dewatering Practice Note (Pacific Highway Projects)
Author	RMS Pacific Highway Office

Issue	Date	Revision Description
1	January 2012	Draft
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Disclaimer

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Contents

1. How to use the Practice Note

The Dewatering Practice Note is intended for use by RMS project managers, staff and contractors on Pacific Highway construction projects. It has been designed as a means to ensure key mitigation and management principles for dewatering are indentified and included in project specific Environmental Work Method Statements (EWMS) to be implemented prior to the need to conduct dewatering activities. It should be employed by RMS project teams as a means to proactively plan, assess and improve on-site procedures involving dewatering. When used correctly the practice note will aid in the enhancement of RMS environmental procedures, ensuring detrimental environmental impacts from RMS construction projects are kept to a minimum.

Refer to this practice note when preparing or assessing EWMS for work activities associated with the removal of ponded stormwater or infiltrated groundwater from any location on site, as well as the subsequent reuse or discharge of that water.

2. Introduction

2.1. Background

Dewatering is considered as any activity involving the removal of ponded stormwater or infiltrated groundwater from any location on site. For the purposes of this practice note and other RMS documentation, dewatering also encompasses any activity involving the subsequent reuse or discharge of such water.

Dewatering is a necessary part of any construction or maintenance project as captured stormwater and infiltrating groundwater will fill and pool in low-lying areas of construction sites over time. Without dewatering, pooling water may otherwise adversely affect project objectives. Reduced sediment control effectiveness, damage to formations and excavations, decreased site-access and increased downtime may all result without dewatering activity.

2.2. Objective

It is a requirement of all RMS Pacific Highway construction projects that ALL dewatering activities are undertaken in a manner that does not pollute the environment. As such project teams working on Pacific Highway projects must develop and comply with appropriately planned, approved and supervised procedures to govern such activities. Documentation of such procedures shall be in the form of an environmental work method statement (EWMS). An EWMS shall be both activity related and project specific and ALL dewatering activities must be addressed for each project. Minimum requirements for each EWMS have been outlined within this practice note, although the use of innovation is encouraged to continually enhance RMS environmental best practice.

Specific aims of this practice note are to deliver best practise and due diligence requirements on Pacific Highway construction projects that enable:

- dewatering activities to be managed to avoid pollution and/or environmental harm as defined under the Protection of the Environment Operations Act (NSW, 1997), (POEO Act) and Regulation;
- that promote sustainability in reusing valuable resources; and
- compliance with conditions of approval, permits, and licence conditions.

3. Considerations in planning dewatering activities

Every dewatering activity must be planned to achieve satisfactory environmental outcomes. In the preparation of an effective and acceptable dewatering EWMS, the following actions must be undertaken:

- Identify areas of the site that will require dewatering
- Identify receiving environment where water will be discharged with consideration and assessment of the sensitivity of the receiving environment (E.g. threatened frog/fish species habitat, Marine Park Areas, etc) - wherever possible dewatering to environmentally sensitive areas should be avoided.
- Consider dewatering methods that will minimise potential environmental impacts
- Assess opportunities for reuse

- Assess limitations for any proposed reuse methods
- Select discharge locations and provide adequate energy dissipation
- Determine and document water quality criteria for discharge and/or reuse
- Assess the treatment techniques required to meet the water quality criteria
- Assess water sampling and testing requirements
- Where discharge to sensitive areas is unavoidable, discharge methods, monitoring, sampling and testing should all reflect the specific nature of that receiving environment, its sensitivity and potential threats. This includes specifically targeting relevant parameters based on consideration of the nature of these sensitive environments.
- Identification of any potential contaminants. It is possible that previous land use activity and or the natural geology may produce contaminants. Where there is evidence to suggest there may be contamination within the catchment of an area requiring dewatering the testing regime should identify any risk and be targeted to ensure that risk is managed.
- Indication of likely volumes and duration of dewatering
- Monitoring requirements / regime
- Ensuring that dewatering does not result in discharged water re-entering the site / disturbed surfaces.
- Considering and addressing potential impacts on natural flows / water levels down stream.
- Considering and addressing mixing rates and dilution to the receiving environment.
- Training requirements / assessment of competency
- Incident management response
- Arrangement and management of the pump inlet
- Bunding of the pump

The subsequent sections (*sections 3.1 to 3.8*) will outline considerations associated with each of the actions listed above. These actions are highly recommended in the early stages of preparing an EWMS although do not constitute necessary deliverable inclusions in an EWMS document. (for minimum deliverable requirements in an EWMS document refer *Section 4: Minimum requirements for dewatering environmental work method statements*)

In addition the *Appendix* of this document provides photographs taken of dewatering activities on RMS construction projects. The photographs may be used to illustrate example designs, aiding in the design consideration process.

3.1. Identify areas of the site that will require dewatering

Dewatering locations will be identified through detailed design, in the development of the CEMP and during construction phase as earthworks and construction processes result in changing site drainage conditions. Typically locations that will require dewatering on RMS projects include:

- Sedimentation controls (e.g. sedimentation basins and sumps)
- Excavations
- Culvert and drainage constructions
- Low lying areas of road formations

3.2. Consider dewatering methods to minimise potential environmental impacts

There are various methods for dewatering sedimentation controls and inundated areas of construction excavation and formations. Common dewatering methods for sedimentation controls such as basins include pumping, low flow pipes and siphon discharges.

When selecting dewatering methods, consideration should be given to alternatives to pumped discharges where practical. Pumped dewatering presents specific risks relating to the pump inlet falling to the level of deposited sediment. This would result in direct discharge of polluted water to the receiving environment. In situations where pumping is necessary, additional protection measures should be designed into the dewatering methodology to prevent this scenario from occurring. Likewise, deposited sediment in controls such as basins must be routinely maintained (removed) to ensure that inlets to dewatering pumps and pipes are always above the level of deposited sediment.

There are two general methods for achieving water quality objectives for any site discharge, these being:

1) Water quality treatment prior to discharge.

This is required for sedimentation basins and is the preferred method for any construction excavation of inundated area that has sufficient volume and depth of water to provide flocculation of sediments prior to discharge. Any area other than defined sedimentation basins that can be treated prior to discharge should have a designed dewatering method (e.g. a defined pumping point, low flow or siphon discharge). This method would be designed to address appropriate water quality parameters and limits, and the type and volume of treatments required.

2) Treatment with best practise controls prior to discharge.

Best practise controls are those referred to within Blue Book Volume 1 and Volume 2D. Controls may include sedimentation fences, mulch bunds, sedimentation sumps, geofabric wrapped gravel or mulch bunds, use of onsite grassed areas or a combination of techniques. Treatment with best practise controls is undertaken prior to discharge. These controls must be designed, implemented, monitored and maintained to prevent erosion of the receiving environment and pollution of waters.

Treatment with best practise erosion and sedimentation controls during discharge is only applicable for minor stormwater ponding and for activities such as individual culvert extensions where the volume of stormwater captured is minor and the dewatering activity is infrequent. Addressing due diligence, risk pollution and environmental harm, site conditions and receiving environment would still need to be considered when determining whether to treat or not to treat water prior to discharge, When considering discharge location and treatment method. The following factors should also be considered:

- application rates,
- soil types,
- hydraulic loading,
- evapo-transpiration rates (as per s6.2 Blue Book Volume 2D, page 28).

The effectiveness of treatments are to be monitored and assessed and need to rectify controls and management strategy as required.

3.3. Assess opportunities for reuse

Onsite reuse of stormwater or detained groundwater should be considered as a priority for all dewatering activities. Onsite reuse may include applications such as dust suppression, earthworks compaction, vegetation establishment/rehabilitation, and plant/vehicle wash-down.

Reuse of water on construction site may reduce the need for imported or extracted water and provide a lower risk to the environment than direct discharge to the environment. A common minimum requirement for any reuse activity is that any reuse should not cause the ponding or runoff of water, which may then cause concentrated runoff and unauthorised discharge.

3.4. Assess limitations for any proposed reuse methods

Any reuse activity may be limited by climatic or site conditions. During heavy rainfall periods, when there is the greatest need to remove treated stormwater from sedimentation basins, construction sites may be closed or access limited due to the wet conditions. In such cases, onsite reuse for dust suppression or compaction is neither feasible nor possible. In these cases the water must be discharged to meet the sedimentation basin maintenance timeframes specified in either the environmental protection licence or the CEMP (for non-licensed site).

Planning for any reuse activity and the EWMS for dewatering must take these limitations into consideration, and an EWMS developed for the management of discharge which may be required as a result of high rainfall events. Planning may include controls such as lining basins, sumps, and excavations with gypsum and/or ensuring the capacity of sumps, excavations are re-instated prior to forecast rain events.

3.5. Select discharge locations and provide adequate energy dissipation

It is important to ensure that dewatering activities do not cause erosion at the discharge location or in receiving environments. Consideration must be given to the potential for erosion at discharge locations when designing dewatering outlets. Preference for treated discharge should be given to locations with established drainage and outlet structures. Locations of designated discharge points should be included on all relevant erosion and sediment control plans for the specific construction activity.

Energy dissipation must be provided at all dewatering discharge points. This may include the use of surface protection such as concrete aprons, rock bunds, geofabric, shade cloth, gabions or form ply and will be dependent on the condition of the receiving environment.

Discharge locations should be chosen with consideration to the receiving environment that may contain environmentally sensitive receivers such as threatened frog/fish species, Marine Park, etc.

Where it is not possible to avoid discharges to sensitive areas, discharge methods, monitoring, sampling and testing should all reflect the specific nature of the receiving environment and relevant parameters should be targeted to monitor, control and minimise any potential impacts.

It is possible that previous land use activity and or the natural geology of the receiving environment may produce contaminants requiring identification and assessment. Where there is evidence to suggest there may be contamination within the catchment of an area requiring dewatering then the testing regime should also identify any risk and be targeted so that the risk is managed.

3.6. Determine and document water quality criteria for discharge and/or reuse

Sites with environmental protection licences will have defined water quality objectives for licensed discharge points. The water quality parameters are also only applicable to basin discharges registered under the license. A discharge that does not achieve the environmental outcomes permitted by an EPL is likely to be considered pollution under s120 of the POEO Act. Any discharges containing contaminants other than those specifically identified in the EPL must not result in pollution to waterways. Best management practice applies when discharging water from all other sites or non-licensed discharge points. This includes defining representative water quality criteria for the receiving environment and ensuring all discharges comply with these requirements as required under the license. For the majority of EPLs for Pacific Highway projects only the outlets of basins is a licensed discharge point registered under the EPL. Standard project water quality objectives criteria for Pacific Highway projects are as follows:

- Total suspended solids 50mg/L
- pH 6.5 – 8.5
- Oil and grease no visible trace

Additional specified receiving water quality criteria may be required for activities that have the potential to impact water quality through a range of pollutants including:

- general earthworks in soils with contamination issues
- earthworks in naturally occurring problematic soils such as acid sulphate soils, saline soil or high levels of other sulphide minerals
- lime storage areas
- tannin leachate
- hydrocarbon spills
- concrete works (including batching operations)
- stabilised pavements
- precoat aggregates and spray sealing
- polymers
- curing compounds

Generally a review of environmental assessment and approval conditions and onsite conditions will provide further information on potential pollutants that may be present onsite or in site waters. Other methods to determine water pollutants may include the use of a testing probe, indicator strips, laboratory analysis, local knowledge and consultation with environmental officers and regulatory agencies.

If reuse activities are properly designed and managed then ponded stormwater or groundwater may be able to be reused onsite without specific treatment.

3.7. Assess the treatment techniques required to meet the water quality criteria

Treatments should be designed to achieve the water quality outcome specified, as well as to cater for the time constraints that may be applicable to the activity (i.e. 5 day management period for sedimentation basins). Treatments should be applied to waters, and should be applied only by experienced and competent personnel. Care needs to be taken to ensure treatment methods do not adversely affect water quality or the receiving environment.

Examples of common treatment applicable to RMS projects may include:

- Flocculation of turbid waters to minimise the settling duration of suspended particles, as well as facilitate the clearing of waters exposed to dispersive soils. Flocculation enables water quality standards to be achieved within an acceptable time period. A suitable flocculent should be chosen for sites based on an impact assessment of the receiving environment. In most cases RMS projects would utilise gypsum, which is considered to be inert. There are other flocculants available; however the use of these must be subject to consultation with relevant stakeholders, including EPA and NSW DPI (Fisheries) prior to use.
- pH adjustment using a base such as hydrated lime (for acidic waters) and inversely an acid such as hydrochloric acid (for alkaline waters). Low volume trials for each location will need to be carried out to determine dosage rates. Special care must be taken when adjusting pH to understand the buffer capacity of the waters, ensuring the neutral point is not over-shot. Any personnel involved in the adjustment of pH must be suitably trained and competent in the use of any additives.
- Absorption of oils and grease is used to remove traces of hydrocarbons that may have been mobilised by rainfall. Sources of oil and grease on a project may include spills and leaks from machinery, runoff from precoat aggregate stockpiles and runoff from adjacent travel lanes. Generally oils and grease will be removed from the surface of water detention by the use of floating booms, pads and absorption socks.

Additional information is provided in Blue Book references:

- Appendix B, page 41 of Blue Book Volume 2D for basin management immediately after rain
- Appendix E of the Blue Book Volume 1 with regards to the best practice methodology of flocculation of basins.
- Attachment 5, page 51 of Blue Book V2D for managing pH.

3.8. Assess water sampling and testing requirements

Water quality sampling and testing may be required to ensure that the water quality objectives are met both prior to and during either reuse or discharge of the water. Techniques may include sample collection and laboratory testing or in-situ field assessment.

A list of approved testing methods for various analytes can be referenced from “Approved Methods for the Sampling and Analysis of Water Pollutant in New South Wales” (EPA 2004). All sampling should be representative of the water to be discharged and testing methods in accordance with this document. Licensed premises require approved testing methods as per the conditions of the environmental protection licence (EPL) unless formal agreement has been reached with the relevant agencies. Any such agreement must be documented, and records kept onsite at all times.

Using turbidity as a tool for Total Suspended Solids (TSS) requires an established NTU/TSS correlation and ongoing laboratory verification to ensure the NTU/TSS correlation being applied for the project is correct.

4. Minimum requirements for dewatering environmental work method statements (EWMS)

4.1. EWMS format

The format of site-specific EWMS is flexible according to the procedures used by each project team. This practice note and RMS specification G36 do not require an individual EWMS for each dewatering location on each site although it is necessary for ALL dewatering activities to be accounted for within a documented EWMS.

The EWMS should provide clear guidance for each dewatering activity utilising each of the following:

a) a map showing areas of the site/project that will require dewatering. This map should identify environmentally sensitive areas and features to be considered when planning discharge locations
b) detailed description and staged methodology of selected dewatering methods. This should include a clear and concise step by step procedure
c) description of onsite water reuse requirements
d) a map showing proposed discharge locations for any offsite discharge
e) design requirements for each offsite discharge location to prevent erosion at the discharge location or in the receiving environment
f) water quality objectives relevant to the type of dewatering activity
g) description of the water quality treatment techniques to be used
h) water sampling and testing regime to validate water quality prior to and (if required) during dewatering. Water quality sampling records should include, times, persons, method, parameters, treatment, consistent location, results etc.
i) Treatment volumes, time of application, who, how etc.
j) details of delegated approval of dewatering activities eg. Internal permit signed off by Environment Construction Manager.
k) proposed monitoring and supervision regimes.

If changes are proposed to the dewatering method used at any location or new dewatering requirements are identified during construction the project team must submit either of the following to the Principal before commencing the activity:

a) a revised and updated the site/project EWMS, or
b) a new stand-alone EWMS for the activity.

5. Document the site activity approvals process

All sites discharging water must have a robust procedure in place for the approval of all controlled discharges from dewatering activities and include a mechanism for quality assurance and verification. This process is to be clearly documented in the EWMS and must nominate specific personnel who can approve dewatering activities and specifically the controlled discharge of water. Delegates responsible for dewatering approval must be suitably trained and experienced in their duties. The approval process for dewatering activities is to be included in the worksite induction and training of onsite personnel. The inclusion and enforcement of these procedures will ensure that the risk of unauthorised discharges is significantly reduced.

The minimum requirements of this approval are:

- water quality is demonstrated to meet the objectives in the EWMS and this practice note
- inspections of intake and discharge locations, equipment and receiving environments are completed
- trained personnel are available to supervise and monitor the activity as specified on the EWMS.

5.1. Document training and induction requirements

All staff responsible for approval and/or execution of dewatering activities must be trained and inducted into use of the EWMS. The EWMS should include an induction register as a record of staff that are approved to conduct or approve dewatering activities.

5.2. Document the requirements for supervision of dewatering activities

The EWMS must provide a clear description of all supervision and monitoring required for each dewatering activity. All dewatering activities must be inspected by inducted, experienced and competent personnel. Prior to commencing any dewatering activity of the entire system including intake and outlet, pump, and discharge locations must be inspected.

All dewatering activities must be directly supervised for the entire duration of the dewatering. To remove the need for direct supervision, sites may carry out risk assessments and implement mitigation measures to ELIMINATE risks of causing environmental harm. Due diligence must be demonstrated to eliminate the possibilities of the following incidents:

- intakes dropping into deposited sediments and discharging sediment-laden waters
- erosion of the discharge locations and downstream environment
- inadvertent or intentional controlled discharge of untreated waters.

5.3. Record keeping for dewatering activities

You must keep the following records:

a) a copy of the dewatering EWMS
b) date, time and estimated volume of water released for each discharge location
c) water quality test results for each discharge
d) records to verify persons monitoring, and monitoring data including water quality parameters and criteria, timing and location of monitoring
e) records indicating who provides approval for each dewatering activity, and
f) evidence of discharge monitoring or risk assessment

Appendix: Photographs of Dewatering Activity on RMS Projects

Figure 1. Application to a sediment basin allows faster settling of sediments and improvements to water quality prior to discharge.

Figure 2. Consideration should always be given to measures to prevent pumped inlets from falling into sediment zones at the bottom of basins. In this example an anchored bucket was seen to be effective.

Figure 3. Informal use of bunding and geotextile was assessed as a suitable outlet treatment for scour protection in this example. The use of a tyre provided both energy dissipation for the discharge flow and anchorage for the discharge pipe.

Figure 3. Use of formal signage indicating discharge procedures was an effective management tool to prevent unauthorised discharges.

Figure 4. A sump adjacent to a working area may require higher levels of maintenance in order to remain effective. Dewatering to a larger sediment basin will be a more viable treatment measure when compared to flocculating the sump itself. Consideration to minimising exposed fines around the immediate catchment (e.g. bottom left corner of the figure) will also reduce sediment entering the sump if deemed practical for construction purposes.

Figure 5. A siphon and float system used for discharging a basin without use of pumps. Floats may be useful for preventing inlets from falling into sediment zones.

Figure 6. An inlet designed with up-turned pipe to ensure settled sediment is not sucked up during discharge. Note that sediment storage zone needs regular maintenance to ensure levels do not reach the inlet level.

Appendix H
Sediment Basin Management and Discharge Procedure

CONSTRUCTION PROCEDURE
SEDIMENT BASIN MANAGEMENT AND DISHCARGE

Purpose: This procedure details the actions required to address the management of soil and water issues during the construction phase on the project, including dewatering excavations and water capture points (including discharge locations in the Environment Protection Licence), sediment basin management and flocculation.

Project No.:	RMS 00031	**Project Description:**	Pacific Highway Upgrade - Woolgoolga to Ballina Early Works – Wave 1 and Wave 3 (part)
Scope of Procedure	This procedure is applicable to dewatering, sediment basin management and flocculation. This procedure will ensure that: • Sediment ponds are constructed and managed in accordance with design plans, CEMP and licences to lessen the impact of the discharging of sediment basin water on the local environment • Dewatering of locations not included within the Environment Protection Licence (EPL) as discharge locations (such as below ground excavations where groundwater or stormwater has been captured or above ground capture points such as depressions on the alignment) would not result in the breach of the EPL criteria. Where the EPL criteria are exceeded, water treatment will be required as outlined in the procedure below. • The flocculation process to be used at sediment basins and water discharge points to ensure that discharged water has a Total Suspended Solid (TSS) level below the EPL criteria, detailed in Appendix B4 – Construction Soil and Water Quality Management Plan. The flocculation of water with high TSS involves the addition of gypsum (or suitable RMS approved alternative) and adequate mixing to ensure that the solids bind together and settle at the bottom of the basin. Clean water remaining above the sediment level can then be discharged from licensed discharge points in accordance with the requirements of the EPL. • Sediment basin water is to be preferentially used for construction. EWMS will be developed for dewatering areas other than sediment basins in accordance with RMS Dewatering Practice Note (Appendix G of Appendix B4 Construction Soil and Water Quality Management Plan).		

Procedure

1. Construction Sediment Basins
Refer to the SWMP, EPL, ESCPs and relevant EWMS for the location of a sediment basin/s. Sediment basins and associated connecting stormwater drainage shall be installed prior to commencement of construction activities within the defined catchment for the basin. For each sediment basin the location and design detail (volume – length, width & depth) will be outlined in the relevant design drawings. Construction of operational basins shall be in accordance with RMS G38 Cl3.7.1. The Project Soil Conservationist or ERSED control specialist will be consulted when designing new basins to ensure the following criteria are met: • Requirements of Landcom's The Blue Book Managing Urban Stormwater: Soils and Construction Volume 1 (the Blue Book). Refer to Section 6.3.3 volume 1 of the Blue Book for detailed design of sediment basins. • Embankments are to meet required compaction levels – 95% MMD is considered standard • Spillways are to be appropriately designed to cater for the nominated rainfall intensity • Markers will be present to indicate design stormwater capacity level and 60% of the sediment storage capacity (basin maintenance trigger). Note that the water may be used for construction purposes (following any testing that is required), such as dust suppression or compaction.
2. Water Quality Criteria For Discharge
Before any water can be discharged from sediment basins it must meet the criteria listed in Appendix B4 – Construction Soil and Water Quality Management Plan.

If the criteria are met, then the water is suitable for discharge. If the criterion is not met, the water will have to be treated

3. Treating Water

Prior to discharge of water, the potential contamination of water must be considered. The most likely sources of contamination will be Total Suspended Solids (TSS), oil and grease, pH and metals (in Acid Sulphate Soil Areas). Where the main source is from stormwater, TSS and oil and grease would be considered likely pollutants. Where groundwater is the main source, influence from ASS in the form of pH and metals must be considered as potential pollutants.

pH Levels

- If the pH of sediment pond water is outside the permitted range it needs to be neutralised. If the water is high, acid is used to lower the pH, if the water is low a base is used to raise the pH
- To treat water with acid, safety requirements must be followed as outlined in relevant SDS and SWMS
- Treatment to lower pH: Hydrochloric acid is used to lower pH. A 500mL dose of acid lowers 7000L of water by a pH of approximately 1.5
- Treatment to raise pH: Aglime or Hydrated Lime

Where only pH neutralisation is required, treatment can be done at any point.

Suspended Solids

If the TSS of water is greater than permitted by licence and permits then flocculation will be required as outlined below. Additionally if a sediment basin is greater than 30% full and a water truck/s are not able to use the water in 4 days then flocculation will also be required.

- Transfer water to the treatment basin first to avoid solids being stirred up during transport/pumping.
- Treating water with flocculent (e.g. gypsum) will make the sediments drop to the bottom. In order for gypsum to work it must be dissolved
- Dosing rates of gypsum may vary depending on soil types, suspended solid concentration and water chemistry attributes such as salinity and buffering capacity. Trials will need to be performed on each basin (and records kept in the Sediment Basin Register) on the amount of gypsum used for each basin and if that dose was adequate to achieve TSS below the EPL criteria. As a guide a dosing rate of 0.1 to 0.5kg per cubic metre shall be used with initial rates 0.3kg per cubic metre (30kg per 100m3). The amount of water present in each basin can be calculated by knowing the capacity of the basin (design drawings/construction dimensions) and by checking the capacity markers. Note that an even application over the captured water is essential for effective flocculation.
- Following treatment with gypsum, sufficient time must be allowed for adequate flocculation to occur to settle sediments within 24 hours of the conclusion of each rain period. Ongoing visual monitoring of the basins should occur during this time. A site-specific relationship should be developed between turbidity and suspended solids to enable comparison checks to be with turbidity values to predict when TSS levels have dropped below the EPL criteria.
- If gypsum is found to be an unsuitable method of flocculating captured water, alternatives shall be investigated. Alternates should be carefully investigated to ensure there are no negative environmental effects including pH or metal influences. The use of flocculent other than gypsum must be approved by the ER and in consultation with the EPA.
- The handling of gypsum or suitable alternative should be handled in accordance with the SDS and OHS procedures.

Hydrocarbons

- If an oily sheen is found on the surface of the water a hydrophobic oil boom shall be used to skim off the sheen prior to discharge.
- If a heavy oil layer is found on the surface of the water the ESR shall investigate and have the oily water removed by a licensed liquid waste contractor and disposed of at an appropriately licensed facility.

Metals

- Consult with the ESR for treatment options for heavy metals.
- Test water once treatment has been undertaken to ensure criteria is met.
- Where metals treatment is required, this will be done prior to transfer so as to not mix metal contaminated water with any other captured waters.

4. Discharging Water

Where de watering is required from non-licensed points, the quantity and quality of water is to be considered. For large quantities or poor quality, as assessed by the ESR, the water will be removed by water trucks and used for onsite dust suppression or pumped/carted to licensed basins or points for discharge. The water must be tested by the ESR on the day of discharge.

Where de watering is required from non-licensed points and the amount of water is considered to be minor (as determined and approved by the ESR) and based on sample results will meet EPL criteria , the water is to be released through appropriate ERSED controls (such as sediment trap or fence, mulch, grass filters).

Once water has been tested and meets all the criteria it may be discharged. Ensure the discharge point will not result in scour or erosion.

The ESR is to re-test the pH and turbidity (NTU) in-situ immediately prior to discharge and complete the Permit to Discharge Form

If sedimentation basins are to be pumped out rather than discharged through the low flow outlet, a float will be attached to the hose to ensure that sediment on the basin floor is not sucked through the pump. The basin is to be regularly monitored during discharge.

Pumps must only be operated by dedicated crews toolboxed on this procedure. During dewatering pumps must be manned at all times to ensure that sediment is not picked up during discharge and water is discharged through ERSED controls. The Sediment Basin Management Register will be completed when treated water is discharged from the basin

5. Maintenance of Sediment Basins

Maintenance of the sediment basins shall be ongoing for the duration of the Project and shall comprise the following:

- A marker will be installed inside the basin to mark 60% of the sediment storage capacity. Once this marker is reached and/or where there is a large build-up of sediment at the basin inlet, sediment will be removed.
- Sediment that is removed from basins shall be disposed of at locations as approved by the Project Engineer and ESR where it will not flow off site without proceeding through appropriate ERSED controls.
- The results of maintenance inspections shall be recorded on the Weekly Environmental Inspection Checklist.

6. Monitoring

Sediment basins shall be inspected at the following times:

- The project soil conservationist shall inspect the sediment basins at least fortnightly and prepare a report.
- Weekly during dry weather and will be recorded on the Weekly Environmental Inspection Checklist
- After a storm event (no later than the following working day if the event occurs outside working hours). Inspections will assess the integrity of the basin and the water holding capacity available within the basin. Capacity of a basin is to be restored within 4 days of a rainfall event but sooner if a major rainfall event substantially diminishes the residual stormwater capacity.
- After rainfall events, sediment basin capacity will be checked with basins holding 30% capacity requiring discharge. Prompt testing of basin water and dewatering (once acceptable water quality has been achieved) will occur to ensure adequate capacity for the next storm event is available.
- Prior to discharge where, pH and TSS will be measured. pH measurement will be taken by a calibrated pH meter and TSS will be analysed by laboratory methods. During initial monitoring, a correlation will be established between TSS and turbidity so that turbidity can be used as an indicator of TSS prior to discharge. Oil and Grease shall only be tested for if an oily sheen is visible on the surface of the water. Results should meet the criteria set out in the SWMP prior to discharge. Samples should be taken from 30cm below the surface of the water in bottles appropriate for the analytes to be tested. Monitoring shall occur less than 24 hours prior to controlled discharge and daily for any continued controlled discharge.

- Prior to discharge from ASS leachate basins, water samples shall be sent to the laboratory to be tested for pH, TSS, Salinity, heavy metals.

7. Record Keeping

Relevant data will be recorded on the Weekly Inspection Checklist and given to the ER

Discharges should be recorded on the Sediment Basin Monitoring / Decant form and will include details such as water treatment method (such as flocculation) with time, duration and amount of flocculent used, water quality monitoring details (time, tests undertaken, results, time of dewatering to satisfy EPL monitoring / recording requirements, discharge volumes and dates and discharge water quality include turbidity for each sediment basin.

Laboratory / field test results will also be recorded on the Sediment Basin Monitoring / Decant form.

8. Removal of Basin

Sediment basins will not be removed before 90% of the upstream areas have been stabilised or otherwise stabilise in accordance with the Blue Book. The basin must be removed or otherwise incorporated into the permanent stormwater drainage system. In either case, sediment should be cleared and properly disposed of and the basin area stabilised.

Water and sediment must be removed from the basin prior to removal. Dispose of sediment and water in a manner that will not create an erosion or pollution hazard.

Bring the disturbed area to a similar condition to that previously existing, then smooth, compact, and stabilise and/or revegetate as required to establish a stable land surface.

Appendix I

Stockpile Management Protocol

STOCKPILE MANAGEMENT PROTOCOL

Purpose: This protocol provides a process for the establishment of stockpile areas within and outside the approved project boundary to ensure that environmental impacts are minimised during construction..

Project No.:	RMS 00031	**Project Description:**	Pacific Highway Upgrade - Woolgoolga to Ballina Early Works – Wave 1 and Wave 3 (part)
Scope of Procedure	This procedure and the associated Stockpile Location Checklist describe the process for obtaining approval for new stockpile sites and environmental factors to be considered. The procedure also describes mitigation measures to the potential environment impacts of stockpiles. Stockpile sites may typically be required to store material including, but not limited to: • Excavated materials to be used in fill embankments and other design features • Acid sulfate soils subject to treatment prior to reuse • Excavated material unsuitable for reuse in the formation • Excess concrete, pavement, rock, steel and other material stored for either future use in the Project or prior to removal from site, and • Topsoil, mulch, excess timber for landscaping and revegetation works.		

Protocol

1. Proposed Stockpile Information

Prior to proposing a new stockpile location, the suitability of existing stockpile locations should be reviewed.

If existing sites cannot be used, the Environmental Site Representative (ESR) shall compile the following data for the proposed stockpile site:

- type(s) of material
- expected quantity of each type of material
- required dimensions of the stockpile area
- whether the stockpile will be temporary or permanent
- land ownership.

The RMS Stockpile Site Management Guideline is available to assist in the site selection, establishment, operation, maintenance and decommissioning of permanent and temporary stockpile sites.

2. Assessment of Stockpile Site

The ESR shall use the Stockpile Location Checklist to assess the stockpile location against environmental constraints maps and in accordance with RMS G1 cl 17.2 and G38 cl 3.2

All sections of the Stockpile Location Checklist must be completed in full. A map showing the stockpile location must be appended to the checklist, including RMS approval where appropriate. Where a proposed stockpile site does not meet a criterion, measures to mitigate any resulting environmental risk and a justification for accepting any residual risk must be recorded on the form.

3. Approval of Stockpile Site

Stockpiles within the Approved Project Boundary

The ESR is to review the completed Stockpile Location Checklist and the Project Manager will approve or reject the location.

Signed copies of the checklist are to be stored in the Checklists folder.

The ESR is to incorporate the approved stockpile site on the Auxiliary Facilities Register. Site-specific mitigation measures identified in the checklist should be recorded in the Stockpile Register. Appropriate ERSED controls will also be specified by the ESR on PESCP as required. Site-specific environmental requirements / controls are to be managed by the construction team and monitored for compliance by ESR.

Stockpiles on Roads and Maritime-owned Land outside the Approved Project Boundary

Stockpile locations identified outside the project corridor may be subject to an RMS approved consistency review process and consideration of Environment Protection Licence conditions must be considered in identification of proposed locations.

Construction representatives will advise the ESR minimum one month prior to the proposed movement of materials outside the approved project boundary. The ESR will ensure that the proposed sources are tested and assessed against the Spoil Classification Procedure.

For temporary stockpiles the following process will be implemented. The ESR will provide a completed Stockpile Location Checklist, Lot and DP numbers, and map of the site will be presented to Roads and Maritime. If the stockpile site is approved by Roads and Maritime the approval is to be attached to the Stockpile Location Checklist and any approval conditions included in the Stockpile Site Register. The construction team will be responsible to manage these approval conditions and the ESR will monitor compliance.

A Section 143 certificate must be completed and signed by the Roads and Maritime prior to stockpiling occurring. The Environmental Checklist for the Movement of Material Offsite is also to be completed by the ESR and Senior Construction Representative and reviewed and approved by the Project Manager prior to materials moving outside of the approved project boundary. Any additional potential environmental impacts will be identified through the implementation of detailed assessments such as ecological surveys etc. The Material export register will be updated by the ESR. Appropriate ERSED controls will also be specified by the ESR on PESCP as required.

For permanent stockpiles the above environmental impact assessment will apply with additional planning /environmental approvals will be identified and obtained by the Project Manager as required.

Stockpiles on Other Land outside the Approved Project Boundary

The ESR must attach to the completed Stockpile Location Checklist, copy of the relevant environmental / planning approval for stockpiling at the proposed location prior to submitting the checklist to the Project Manager.

Section 143 certificate and material export environmental compliance checklist must be completed by the ESR and construction representative and be reviewed and signed off by the Project Manager prior to material being transported outside the approved project boundary. Appropriate ERSED controls will also be specified by the ESR on PESCP as required.

Where outside the project boundary the stockpile and surrounding area is required to be assessed in accordance with G36 clause 3.2.2 with an environmental assessment in accordance with the relevant legislation and obtain any additional approvals required prior to the use of any such land.

Attachment – Stockpile Location Checklist

Stockpile Location Checklist

GOLDING

The location of stockpile will be determined following review of constraints and conditions:

1. Project environmental constraints maps
2. MCoA B73 – Ancillary Facilitites
3. G38 Specifications

Where proposed sites either impact on environmental constraints or do not comply with MCoA B73, the project must provide justification for the stockpile location and, if relevant, additional mitigation measures.

Stockpile Number	
Chainage	
Material to be Stockpiled Dimensions (HxWxD)	

Criteria		Does the Site Meet Criteria?	If the proposed site does not meet constraints criteria, provide justification / additional mitigation measures to demonstrate how potential impacts will be managed appropriately.
Review Against Constraints Maps	Site should not impact on threatened flora or fauna		
	Site should not impact on heritage items		
	Site should not impact on wildlife corridors		
	Site should not impact on compensatory habitats		
	Site should not impact on vegetation communities		
Review Against MCoA B73	a) Site to be located more than 50m from a waterway.		
	b) Site must not impact on connectivity structures or vegetation leading to a connectivity structure.		
	c) Site to be located within or adjacent to project boundary.		
	d) Site to have ready access to the road network		
	e) Site to be located in areas of low ecological significance and require no clearing of native vegetation.		
	f) Site to be located more than 50m from threatened species & EEC and their habitats.		
	g) Site to be located on relatively level ground.		
	h) Site to be located at least 200m from the nearest residence and comply with construction noise management levels at sensitive receivers.		
	i) Sites must be above the 20 year ARI unless a contingency plan to manage flooding issues is prepared and implemented		
	j) Site to have only minor impact on flood storage and not result in obstruction of floodplain flow or blockage of culverts and drains.		
	k) Site to not unreasonably affect the land use of adjacent properties.		
	l) Site to operate in accordance with the construction hours set out in conditions B15 & B16.		
	m) Site to provide sufficient area for storage of material so as to minimise, to the greatest extent practical, the number of deliveries required outside standard construction hours.		
	n) located in areas of low heritage conservation significance (incl Aboriginal cultural) and not impact on heritage sites beyond those already impacted by the project.		
	Locate stockpiles outside of the tree protection zone of trees to be retained. Delineate in accordance with AS 4970		
G38	Locate stockpiles at least 5 metres from areas of concentrated flows and at least 10 metres from waterways that are classified as Class I and		

Criteria		Does the Site Meet Criteria?	If the proposed site does not meet constraints criteria, provide justification / additional mitigation measures to demonstrate how potential impacts will be managed appropriately.
	Class 2.		
	Keep stockpile heights to <2 m, unless otherwise approved by the Principal, and slopes < 2: I		
	Keep topsoil that is not contaminated by noxious weeds in stockpiles for later use.		
	Keep stockpiles outside any area underlain by soft soils		
	Prior to stockpiling - install sediment fences on the downhill side and diversion drains on the uphill side of stockpile		
	Stockpile sites must be designed, established, operated and decommissioned in accordance with RMS's Stockpile Management Guide 2011.		
	Any potential noise and vibration impacts from the use of the stockpile site / does the community need to be consulted? Has this occurred?		
	How will dust be minimised at the stockpile?		
	A written report provided detailing: • Location of area to be cleared including survey and comparisons with Cadastral • Intended use of the land • Reasons for why this working area is needed • Construction techniques and materials • Any Alternative areas • Area of land required including length & width • Period of use • Erosion and sedimentation controls to be implemented • Rehabilitation treatments • How your proposal meets with the order of precedents detailed above • How the proposal complies with the Conditions of Approval.		

Prepared by Environmental Site Representative: Approved / Rejected (please circle) by Project Manager:

Date:

Date:

Appendix J
Emergency Spill Response Plan

GOLDING

CONSTRUCTION PROCEDURE
EMERGENCY SPILL RESPONSE PLAN

Purpose: This Procedure details the requirements for managing and clearing up spills i.e. chemical, fuel or oil spills / leaks that occur on the site.

Project No.:	RMS 00031	**Project Description:**	Pacific Highway Upgrade - Woolgoolga to Ballina Early Works – Wave 1 and Wave 3 (part)

Scope of Procedure

This Procedure is applicable to all activities that have the potential to spill or leak fuels, oils or other chemicals.

Assessment of the Situation → **Spill Management** → **Spill Clean Up** → **Notification / Review**

Figure 1 Spill Management Procedure Flow Chart details the process involved in spill management for the project.

Environmental Incident Classification (Environmental Incident Classification and Reporting Procedure, RMS 2015):

- **Category 1 Incidents** - potentially the most serious incidents. They generally reflect breaches of environmental legislation.
- **Category 2 Incidents** - are generally less environmentally serious that may lead to Category 1 incidents if not addressed.
- **Reportable Events** - This category captures events that occur outside the scope of reasonable controls and mitigation.

Procedure

1. Assessment of the Spill / Situation

- Stop work in the relevant area and take immediate action to prevent adverse impact to the environment and community
- Health and safety of workers is the primary concern, and no action should be taken if it is not safe to do so.
- Cordon off the area around the spill / leak to stop foot/vehicle passage through the affected area.
- Conduct a short assessment of the affected area and notify the Environmental Site Representative (ESR)/ Project Manager (PM) of the results of this assessment. The assessment should include:
  - Quantity of the substance spilt;
  - Type of substance (i.e. corrosive, poisonous, flammable etc);
  - Location, and potential impact on the environment, and the health and safety of personnel;
  - Whether the spill is manageable and the best method of clean up (after referring to the substance’s SDS).
- Refer to the Safety Data Sheet (SDS) or container label for detailed information on the substance spilled and to determine the appropriate Personnel Protective Equipment (PPE) and cleanup / storage and disposal requirements.
- Where the spill is not manageable and presents an immediate danger to people, property or the environment, the following needs to be determined:
  - Whether sufficient spill control equipment and materials, and personal protective equipment exist on site to deal with the spillage;
  - Whether attempts to deal with the spill on site would pose any risk to people;
  - Whether the site’s Waste Management Contractor should be contacted for cleanup, removal and safe disposal of the spilt substance.
- Where it is determined that the spill cannot be managed by the resources on site, efforts shall be made (where safe to do so) to protect storm water drains and sensitive areas. Notify the EPA and other relevant authorities including the NSW Fire Brigade (the NSW Fire Brigade has a pollution incident notification hotline 1300 729 579 – otherwise call 000).

2. Spill Management

Personal Protective Equipment

- Prior to any clean-up, appropriate personal protective PPE is to be worn as per the MSDS. No clean-up should occur without the correct PPE.

Control the Source

- Stop the source of the spill / leak if it is safe to do so.

Protect Drains, Channels or other Pathways for Environmental Reasons

- If there is a possibility that the spill / leak will either contaminate a greater area or move off site, protect drains, channels or other pathways for environmental release.
- If required, geo-fabric, absorbent materials, booms and sandbags should be placed around drains and grates.

Contain the Spread of the Spill / Leak

- Stop the spill / leak from spreading by using:
  - Absorbent materials from spill kit (i.e. booms, pads, pillows, granules etc);
  - Sand bagging, spoil or impermeable silt sausages; and
  - Any useable physical barrier.
- Place booms around outside edges of spilled / leaked substance. Ensure booms are overlapped to prevent leakage.
- Ensure there are no gaps between the boom and the affected surface.

3. Spill Clean Up

Clean Up the Spill / Leak

Deploy booms first to contain spill. If the booms alone cannot absorb the spill/leak, then use absorbent granules to soak up spilled liquid Absorbent granules are best for small spills/leaks Lay down pads or pillows Reduce the size of the spill/leak by gently pushing the booms towards the centre of the spill.	**Use the correct materials** **Booms** - Deploy first to contain or divert spill away from waterway **Granules / Particulate** - Quick and absorbent, good for large spills **Pillows** - Best for thickly spread liquids **Pads** - Best for thinly spread liquids

Disposal of Material Used and Spilled Waste

- Booms, pads, pillows, gloves and absorbent granules to be placed in waste bags. These are then to be disposed of to a contaminated waste bin.
- Spilled liquid waste to be placed into a labelled sealed container.

4. Notification / Review

Stop work in relevant area (if necessary) and take immediate actions to prevent adverse impact to the environment or community.

	Category 1 Incident Response
1	For **NOTIFIABLE POLLUTION INCIDENTS** refer Environmental Incident Classification and Reporting Procedure, RMS 2015. For all other Category 1 incidents immediately advise RMS Project Site Management and relevant RMS Regional Environment Manager who must immediately advise Principal Manager Environment Operations (PMEO) by phone.
2	Complete the environmental incident report form 624 and submit to Regional Environment Manager and the Environment Operations mailbox within 3 days of the date of the incident.
	Category 2 Incident Response
1	Advise relevant RMS Regional Environment Manager
2	Complete the environmental incident report form 624 (and submit to RMS Regional Environment Manager

	and the Environment Operations mailbox within 3 days of the date of the incident.
Reportable Event Response	
1	Roads and Maritime contractors to advise Roads and Maritime Project Site Management

In addition to reporting according to the RMS Environmental Incident Classification and Reporting Procedure incidents are reported in accordance with the Golding procedure – Incident Notification Recording Investigation and Reporting.

Under Section 148 of the *Protection of the Environment Operations Act 1997*, there is a requirement to notify the EPA of pollution incidents causing or threatening to cause material harm to the environment. Under Section 147, 'material harm' is defined as:

(1) For the purposes of this Part:

(a) harm to the environment is material if:

(i) it involves actual or potential harm to the health or safety of human beings or to ecosystems that is not trivial, or

(ii) it results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000 (or such other amount as is prescribed by the regulations), and

(b) loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment.

(2) For the purposes of this Part, it does not matter that harm to the environment is caused only in the premises where the pollution incident occurs.

5. References

Office of Environment and Heritage documents:

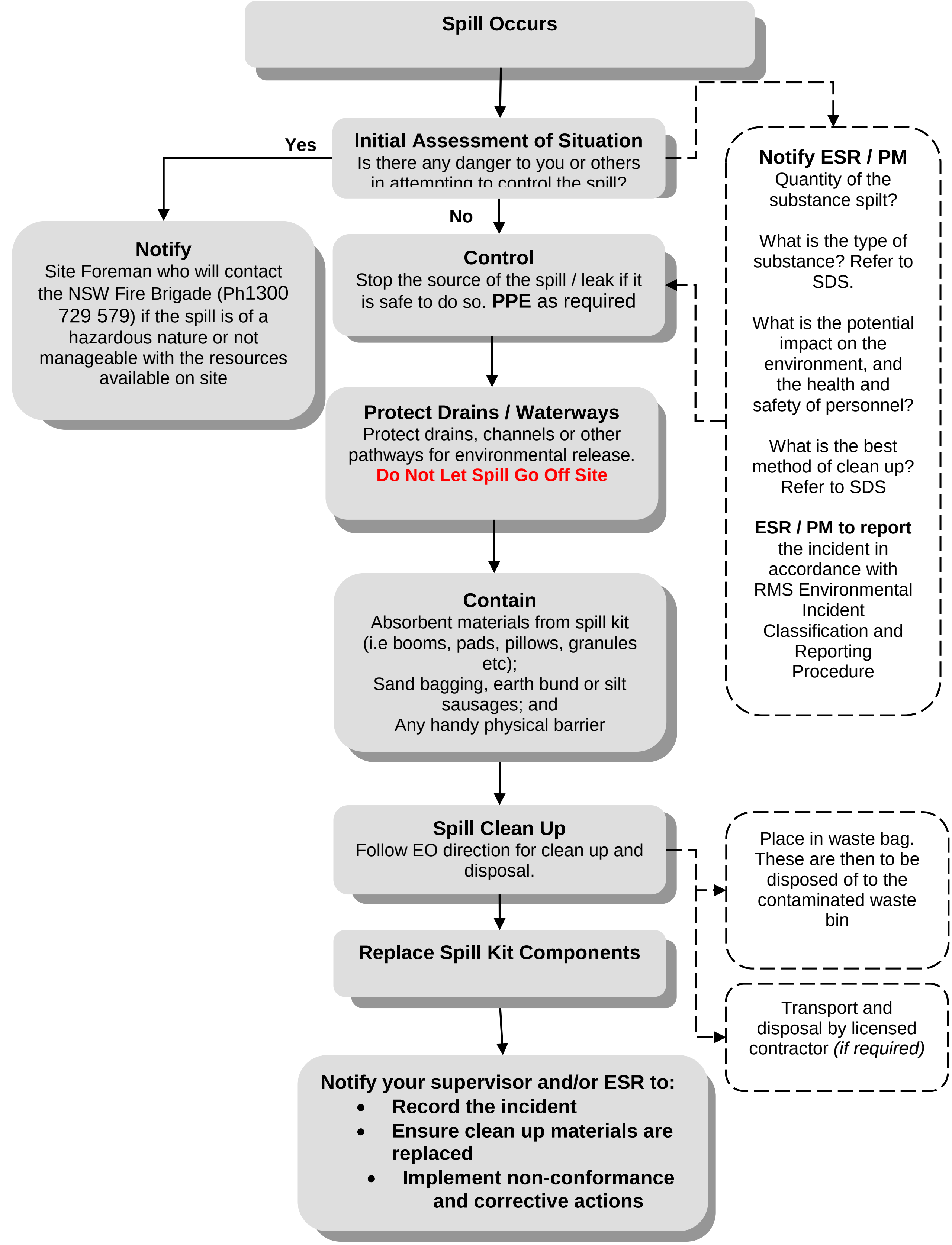
- Storing and Handling Liquids: Environmental Protection - Participants Manual
- Environmental Compliance Report - Liquid Chemical Storage, Handling and Spill Management
- Environmental Incident Classification and Reporting Procedure, RMS 2015

6. Spill Containment Kit

At any site where there is a significant risk / consequence of a spill, an appropriate spill kit(s) is to be located (different kinds are available for different pollutants). The ESR is available for assistance and advice in purchasing the correct spill kit.

CONSTRUCTION PROCEDURE
EMERGENCY SPILL RESPONSE PLAN

Figure 1: Spill Management Procedure Flow Chart



Appendix K
Groundwater and Soil Salinity Report

RMS document: Summary pages attached.

1. Acid Sulfate Soil

An extensive number of testings on acid sulfate soils have been carried out along the project alignment, however there are still areas where testings are yet to be carried out to confirm the presence of acid sulfate soil. Therefore, for the purpose of our assessment, the determination of the acid sulfate soils area has been based on the followings:

- Acid sulfate soil testing results
- In the absence of acid suflate testing results, any area below RL<5 is identified as possible acid sulfate soil area

Table 1.1 presents the summary of extend of acid sulfate soil and potential of its removal or excavation requirement based on the current proposed foundation treatments and location of culverts and piles for bridges.

Table 1.1 Summary of acid sulfate soil along project alignment

Section	Chainage		Notes
	From	To	
4	70200	70450	Foundation treatment proposed does not require excavation or removal of acid sulfate soil.
	70450	70470	Material removal may be required as part of bridge pile foundation.
	70650	72800	Foundation treatment proposed does not require excavation or removal of acid sulfate soil. Material removal may be required as part of culvert foundation treatment at Ch.71330.
	72800	74760	Soft soil treatment area - discharged of groundwater through wick drain
	74760	75210	Material removal may be required as part of bridge pile foundation.
	77150	77460	Soft soil treatment area, no excavation or discharged of groundwater through wick drains is currently proposed
	77920	78000	Foundation treatment proposed does not require excavation or removal of acid sulfate soil.
	78420	78900	Foundation treatment proposed does not require excavation or removal of acid sulfate soil.
	78900	80700	Soft soil treatment area - discharged of groundwater through wick drain
	80700	80750	Foundation treatment proposed does not require excavation or removal of acid sulfate soil.

5	83300	83450	Foundation treatment proposed does not require excavation or removal of acid sulfate soil.
	83450	84120	Foundation treatment proposed does not require excavation or removal of acid sulfate soil.
	84120	84700	Soft soil treatment area, no excavation or discharged of groundwater through wick drains is currently proposed
	84700	85700	Soft soil treatment area - discharged of groundwater through wick drain
	85700	85940	Soft soil treatment area – possible excavation as part of treatment
	85940	87250	Material removal may be required as part of bridge pile foundation.
	87250	87400	Soft soil treatment area – possible excavation as part of treatment
	87400	87600	Soft soil treatment area - discharged of groundwater through wick drain. Material removal may be required as part of bridge culvert construction at Ch.87,400.
	87600	87770	Soft soil treatment area, no excavation or discharged of groundwater through wick drains is currently proposed.
	87770	88150	Foundation treatment proposed does not require excavation or removal of acid sulfate soil. Material removal may be required as part of bridge culvert construction at Ch.87,800 and Ch.88,130.

Section	Chainage		Notes
	From	To	
	88150	89260	Soft soil treatment area, no excavation or discharged of groundwater through wick drains is currently proposed. Material removal may be required as part of bridge culvert construction at Ch.88,800.
	89260	89320	Soft soil treatment area - discharged of groundwater through wick drain
	89320	89410	Material removal may be required as part of bridge pile foundation.
	89410	89550	Foundation treatment proposed does not require excavation or removal of acid sulfate soil.
	89550	89850	Foundation treatment proposed does not require excavation or removal of acid sulfate soil. Material removal may be required as part of bridge culvert construction at Ch.89,820.
	89850	90350	Soft soil treatment area - discharged of groundwater through wick drain. Material removal may be required as part of bridge culvert construction at Ch.90,040 and Ch.90210.
	90350	90600	Soft soil treatment area, no excavation or discharged of groundwater through wick drains is currently proposed
	90600	90760	Foundation treatment proposed does not require excavation or removal of acid sulfate soil.
	90760	91070	Soft soil treatment area, no excavation or discharged of groundwater through wick drains is currently proposed
	91070	92940	Foundation treatment proposed does not require excavation or removal of acid sulfate soil. Material removal may be required as part of bridge culvert construction at Ch.91,370, Ch.91,700, Ch.92150, and Ch.92800.
	92940	93560	Soft soil treatment area - discharged of groundwater through wick drain. Material removal may be required as part of bridge culvert construction at Ch.93,350.
	93560	93980	Foundation treatment proposed does not require excavation or removal of acid sulfate soil.

2. Groundwater and Soil Salinity

The salinity interpretation is based on the corrected electrical conductivity to account for soil texture (ECe) method as detailed in "Book 2 Dryland Salinity: Identifying Saline Sites" available from
http://www.environment.nsw.gov.au/resources/salinity/Book2DrylandSalinity.pdf.

Pertinent tables for soil salinity interpretation are presented below for convenience.

Table 5: Multiplication factors for converting EC 1:5 to Ece .

Soil Field Texture	Description	Conversion Factor
Sands	Very little or no coherence. Cannot be rolled into a stable ball. Individual sand grains adhere to the fingers.	17
Loams	Can be rolled into a thick thread but will break before it is 3 - 4 mm thick. Soil ball is easy to manipulate and has a smooth spongy feel with no obvious sandiness.	10
Clay Loams	Can be easily rolled to a thread 3 - 4 mm thick but with a number of fractures along the length. Plastic like soil, capable of being moulded into a stable shape.	9
Light Clays	Can be rolled to a thread 3 - 4 mm thick without fractures. Some resistance to rolling out. Plasticity evident, smooth feel.	8
Medium Clays	Handles like plasticine. Forms rods without fractures. Some resistance to ribboning shear. Ribbons to 7.5 cm or more.	7

Table 7: EC_e Values of soil salinity classes

Class	Salinity Class	EC_e
Non-saline	0	<2
Slightly saline	1	2-4
Moderately saline	2	4-8
Very saline	3	8-16
Highly saline	4	>16

Relevant table for water salinity interpretation is presented below

Table 3: AWRC saline water quality classes

Water Quality Class	Salinity level (dS/m)	Salinity levels (mg/L)
Fresh	less than 0.8 dS/m	less than 500mg/L
Marginal	0.8 – 1.6 dS/m	500 - 1000mg/L
Brackish	1.6 – 4.8 dS/m	1000 - 3000mg/L
Saline	greater than 4.8 dS/m	greater than 3000mg/L

The summary of soil salinity interpretation across the project site is presented in Table 2.1.

Table 2.1 Summary of soil salinity along project alignment

Section	Chainage		Testing				Interpretation
	From	To	pH	Conductivity (µS/cm)	Chloride (ppm)	Sulphate (ppm)	
3	33800	42000	5.2	319	420	31	Slightly Saline
	42000	46000	5.3	150	300	78	None to slightly saline
	46000	52500	6	27	10	10	Non-saline
	52500	56900	5.8	18	25	<10	Non-saline
	56900	68800	5.5	19	<10	<10	Non-saline
4	68800	70010	6	6	<10	<10	Non-saline
	70010	75175	6.3	23	40	31	Non-saline
	75175	77150	5.5	72	16	17	Non-saline
	77150	77525	7.5	200	170	83	Slightly Saline
	77525	77900	5.4	87	79	20	Non-saline
	77900	78000	4.9	27	11	10	Non-saline
	78000	78400	No Testing (based on geology and testing of similar unit)				Non-saline
	78400	80850	5.2	5263	190	64	Highly Saline
	80850	82000	5.7	31	22	<10	Non-saline
5	82000	83100	5.4	45	48	24	Non-Saline

Section	Chainage		Testing				Interpretation
	From	To	pH	Conductivity (µS/cm)	Chloride (ppm)	Sulphate (ppm)	
	83100	85900	7.7	1299	660	104	Very Saline
	85900	87400					Highly Saline
	87400	89000	5.9	34	23	16	Non-Saline
	89000	90500	6.9	588	850	200	Moderately Saline
	90500	92500	7.4	210	170	59	Slightly saline
	92500	94700	6.0	461	250	28	Moderately Saline
	94700	96700	5.4	180	395	79	Non-Saline

The summary of water salinity interpretation across the project site is presented in Table 2.2. There is no water testing result available for Section 7, Section 9 to Section 11.

Table 2.2 Summary of water salinity along project alignment

Section	Chainage	pH	Resistivity (ohm/cm)	Conductivity (µS/cm)	Chloride (ppm)	Sulphate (ppm)	Classification
4	69210	6.64	no data	556	1	no data	Fresh
	69332	5.6	3030	330	92	3.1	Fresh
	69900	6.14	no data	175	1	no data	Fresh
	69950	5.68	no data	1831	1	no data	Brackish
	70475	7.6	1136	880	1100	6.7	Brackish
	71105	5.2	5882	170	340	6.1	Fresh
	72375	6.76	no data	5565	1	no data	Saline
	72410	6.94	no data	1496	1	no data	Marginal
	73421	6	357	2801	870	2	Brackish
	74680	7.25	no data	506	1	no data	Fresh
	74680	7.06	no data	1536	1	no data	Marginal
	74938	7.3	357	2801	720	2	Brackish
	76655	6.5	no data	7600	1	no data	Saline
	77052	6.5	769	1300	560	25	Marginal
	77400	7.06	no data	2775	1	no data	Brackish
	77400	6.58	no data	4500	1	no data	Brackish
	77670	6.62	no data	4675	1	no data	Brackish
	80055	7.07	no data	1395	1	no data	Marginal
	80160	6.71	no data	1169	1	no data	Marginal
	80165	7.1	714	1401	1800	5	Brackish
	80300	6.6	400000	3	2300	120	Brackish
	80500	7.66	no data	2845	1	no data	Brackish
	80531	7.9	6250	160	no data	2	Fresh
	80590	7.17	no data	9320	1	no data	Saline
	81250	6.5	274725	4	16	7.1	Fresh
5	82850	7	18519	54	1700	330	Brackish
	85800	7.3	no data	18425	1	no data	Saline
	85850	7.47	no data	3393	1	no data	Brackish
	86201	8	1350	741	15000	2	Saline
	86250	7.4	2747	364	87	1	Fresh
	87794	4.7	200	5000	1300	35	Saline
	89300	7.3	2	500000	12000	9.1	Saline
	89300	7.34	no data	5040	1		Saline
	89355	7.8	170	5882	1900	4.4	Saline
	90640	6.78	no data	614	1	no data	Fresh
	90700	7.57	no data	4023	1	no data	Brackish
	90758	6.2	70	14286	10000	720	Saline
	93538	7.3	1.7	600	66	7.6	Fresh
	94200	7.2	300	3333		10	Brackish
	94200	6.5	2.5	400000	10000	190	Saline
	95450	6.7	25	40000	730	34	Saline

4. References

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Appendix L
Oxleyan Pygmy Perch Habitat Waterway Management Framework

Note: This appendix is not applicable to the Wave 1 & 3 (part) Project and therefore has been intentionally omitted.

Appendix M
Hydrological Mitigation Report

Note: This appendix is not applicable to the Wave 1 & 3 (part) Project and therefore has been intentionally omitted.

Appendix N
Schedule of Property Specific Management Measures

Note: This appendix is not applicable to the Wave 1 & 3 (part) Project and therefore has been intentionally omitted.